IoT based LPG Gas Utility system

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***Abstract*—Liquefied petroleum gas (LPG) is a powerful and efficient fuel primarily used in domestic and commercial cooking areas. LPG is highly flammable and easily dispersed in the air, so it can pose a fire hazard even when the source of the fire is remote from the leak. The proposed system therefore offers a technically feasible solution to the same problem using gas sensors connected to a microcontroller. Another problem with LPG cylinders is the inability to measure the amount of fuel inside. It's a small thing, but it's a real family matter. The proposed system provided a solution by weighing the gas cylinder and thereby determining the level of contents. All this data is transmitted through a wireless WiFi network and users can view all the data on remote smart devices such as mobile phones. The paper explains in detail the process and working of the proposed system.**

***Index Terms*—LPG, IoT, LPG hazards, LPG monitoring , IoT system, Gas Level, Gas sensor(MQ-135), Force sensor**

I. Introduction

The aim of this system is to try to do a whole evaluation of the LPG systems which are rooted in nearly 30 crore people in India. [1] Tt is a tedious process to test the extent of gas cylinder reception with no special equipment and book the new one in anticipation. The proposed system leads to reduction of gas leakage cases and detection of the amount of gas in the cylinder. This, though seems like a mere solution; however it will create a huge impact when taken cumulative of the entire nation of at least a million households.

system. Gas leakage ends up in accidents leading to both financial loss further as human injuries. [2] The danger of suffocation, explosion, and firing are all passionate about their physical properties. like flammability, toxicity etc [3]. According to the Ministry of Petroleum and fossil fuel, Government of India over 835 deaths are recorded in 2018-19 in India alone. [4] Inspections by oil companies found that many LPG consumers are unaware of the safety regulations of gas cylinder. It involves a system which might detect gas leakage and prevent it.

LPG is the most popularly used volatile organic compound used for kitchen functionalities. It is used in almost 99% of households in India, thus have a wide range of usability. In India, the usage of LPG as a fuel is a crucial demand for domestic purposes. The primary usage of LPG in the home is to prepare food for the household. According to research, the fire produced by LPG is highly clean, therefore it can improve the health of families [5]. LPG is a combination of organic chemicals such as propane (C_3H_8) and butane (C_4H_{10}). These organic compounds have a number of potentially hazardous features. Volatility(combustibility) is one among them. So, despite its many benefits, LPG has some severe drawbacks, such as gas leaking and running out of gas at the eleventh hour. The Bhopal gas leakage catastrophe is an example of an accident caused by a gas leakage [6]. A gas leak can be dangerous since it increases the likelihood of an explosion. For this problem, a variety of solutions have been presented. Adding various chemical compounds to LPG, such as ethanethiol(C_2H_6S), ethanol(C_2H_5-OH), and so on, is one of them. Ethanethiol or ethanol are added to LPG to give it an odor that is easily detectable in these generally odorless fuels that can cause fire, explosions, and asphyxiation [7]. The sense of smell may not be sufficient for some people for whom it is impaired. As a result, this strategy fails to provide a proper solution to this problem. So the proposed system provides an efficient solution to the problem of gas leakage at the household level.

India is a nation of complete hospitality. Thus greeting guests, inviting them over for lunch, dinner, or for that matter even for a cup of tea, is a tradition. So on such occasions preparing food is an important factor in this process of hosting a meal. However, at such times, according to many experiences, it is especially, at this time, when the guests are to arrive the gas goes off, and the dishes are not yet prepared. This creates immense chaos in the house. There arises a rush of replacing this empty LPG gas cylinder with a new, filled cylinder. These situations call for the need for a system that will monitor the levels of LPG. These levels would help the user comprehend the level of gas remaining in the cylinder. The system would also show how much more gas is remaining when used on full flame [8]. This monitoring can also indicate the amount of gas leaked from the cylinder [9]. The proposed system allows the user to monitor the LPG gas usage at the household level.

Thus, in order to make a positive contribution to the above mentioned rooted process [1] the proposed system aims to prevent further loss of life [4] and increase the comfort of the user in order for them to safely continue using their LPG systems. The following paper talks about how to implement and create such a system.

The proposed system leads to reduction of gas leakage cases and detection of the amount of gas in the cylinder. This, though seems like a mere solution; however it will create a huge impact when taken cumulative of the entire nation of atleast a million households

II. Related Work

The authors of [10] have mentioned the use of an MQ-6 gas sensor, for the sole purpose of LPG leakage detection. The MQ-6 sensor senses LPG leakage in any case and sends alert signals to the microcontroller when it reaches a dangerous level. The formulas for the calculation of power of sensitivity and Resistance of sensor are :

$$P_s = V_c^2 \times \frac{R_s}{(R_s + R_L)^2} \tag{1}$$

$$R_s = \frac{V_c}{V \times R_L - 1} \times R_L \tag{2}$$

[11] [12] From the microcontroller, an alert is sent to the users via GSM [13]. Thus the users would be made aware of any kind of LPG leakage. Weight sensor is used for the purpose of monitoring and detecting the amount of gas present in the LPG cylinder [11]. Usually, the permissible net weight for LPG in the domestic cylinder is 14kg. The average weight of an empty domestic cylinder is approximately 15.3kg. The total gross weight of the cylinder can be rounded off to 29.5kg. Thus when this figure changes the weight sensor senses the smallest changes which are further displayed on the LCD. When it reaches 0.5kg the system sends an alert to the user device [12].

To address the above mentioned issues our project uses the MQ-135 Gas sensor and alerts the user if the regular gas composition of the surrounding atmosphere changes. Our project would also use a 4.08mm force sensor in combination with the Gas Sensor for calculating the weight of the cylinder and notifying the user if a certain threshold is crossed. [14] The proposed system intends to combine these two sensors and create a system that would prevent gas leakage and also serve as an alert sending device to prevent last minute shortage.

Many solutions have been in the industry for years like a solution created by students of KIIT [4]. The proposed solution aims to improve the safety, usability and effectiveness of the LPG gas cylinder usage. The advantages of the system are: As the Weight sensor output is converted to digital in the reference system there is a loss of accurate data on actually how much level of gas is remaining in the cylinder. According to the given paper [15] Arduino UNO has been employed for a similar system. However working with the Arduino UNO development board has a certain set of limitations. The proposed system avoids these problems by using the Node Micro Controller Unit (MCU) which has a built in ESP8266 WiFi module the cost of the project has been reduced By giving the user an application to monitor their gas systems the accessibility and control over the system have been increased significantly

The MQ-6 sensor was utilized by the researchers [16] to find the gas leak. Using the global system for mobile communication(GSM), an SMS is sent to the user . The system operates two channel relays and notifies the user via LCD, Blynk, or web application if the MQ-6's PPM value exceeds 800. In this instance, the DC geared motor was used to turn off the cylinder regulator, and the same motor was used to turn on the regulator if the PPM value of the MQ-5 sensor was less than 500.

The safety of the home and those residing there is the major concern of the researchers [17]. Their research reveals how to develop a simple and effective home monitoring system utilizing sensors, the Internet of Things, and GSM. The sensors like ultrasonic sensors are used to detect the movement at the doors, temperature sensor used for measuring the temperature and humidity in the atmosphere, and a gas sensor to detect the gas leakage in the house. For all of the sensors and processing sensor data, they used Node MCU ESP8266 as an MCU (microcontroller unit). This ESP8266 is connected to cloud-based services through local Wi-Fi connections. This makes remote home monitoring possible [18]. As a backup alarm system when the sensor readings exceed a certain threshold, they also utilized a GSM module [16] with an Arduino to communicate directly with the homeowner's phone. This would provide a system with redundancy.

III. Design Methodology

The project implementation is done on an IoT system. Thus, a suitable design of the same was needed.

Fig. 1 describes all the domains on which the proposed system works

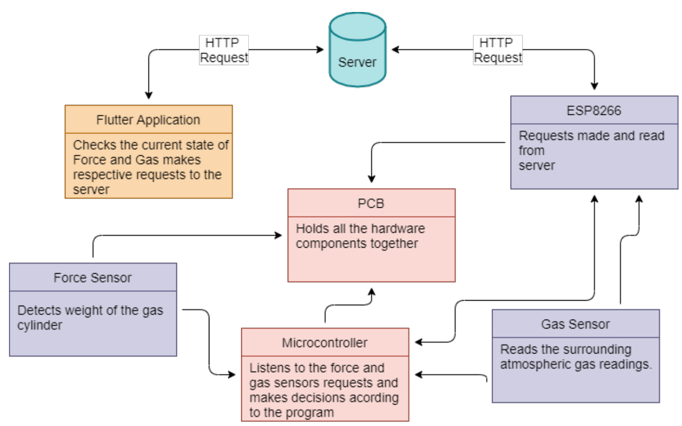

Fig. 1. Domain Model Specification

As shown in Fig. 1 the system consists of 3 major domains which are:

1) Sensor: This is the domain where the physical data is translated into digital format and sent to the microcontroller for further processing. Also the ESP82666 WiFi module is responsible for collecting the data from the microcontroller and broadcasting it to the network.

2) Microcontroller: domain handles the on site processing of the data and manages all the sensors and the ESP8266 WiFi module.

3) Application: is the domain to which the final user interacts, meaning the user is informed of the status and health of his/her LPG system

The proposed system detects the gas above the gas tube of the cylinder. It also provides users with the ability to monitor gas levels in LPG cylinders.The following image explains the device component integration needed to achieve the same.

Fig. 2 describes the architecture of the proposed system. The

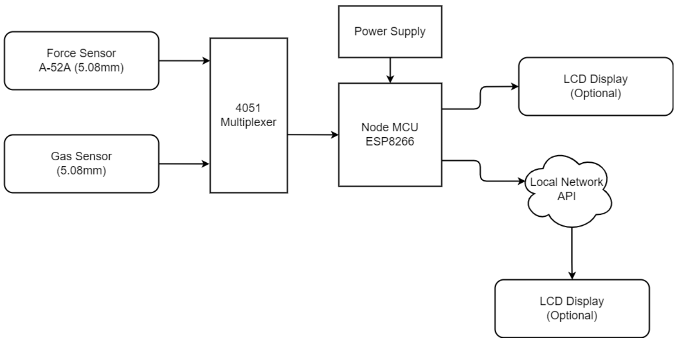

Fig. 2. Block Diagram of Proposed System

4051 multiplexer toggles the analog input on the Node MCU (pin A0) which is controlled by three pins D1, D2, D3 on Node MCU. The maximum amount of time is given for the gas leakage detection whereas a finite amount of time is given to the Measurement of the level of gas in the cylinder. All the statistics is sent to a host on the local network and then is fetched from the user's application to give him/her the most accurate data in real time.

The proposed system has certain hardware requirements which are the Node MCU 0.9 (ESP8266 Module) as the microcontroller controlling all the sensors and using the ESP8266 Module for sending the data over the WiFi network. Then the system uses MQ-135 Gas Sensor to create catch any abnormal changes in the atmosphere surrounding the LPG cylinder and the A-52A 5.08mm Force Sensor for detecting the level of gas remaining in the LPG cylinder before it actually empties out. In order to configure the sensors to the Node MCU microcontroller a $1k\Omega$ resistor is required and 2 LED's indicating the Danger levels of Force and Gas Sensors are connected to the Node MCU with 100Ω resistors preventing them from shorting out.

After the gathering of required components the team created a schematic for the required circuit. After completion of the schematic and checking the connections the PCB board layout was designed and finalized as shown in Fig. 3

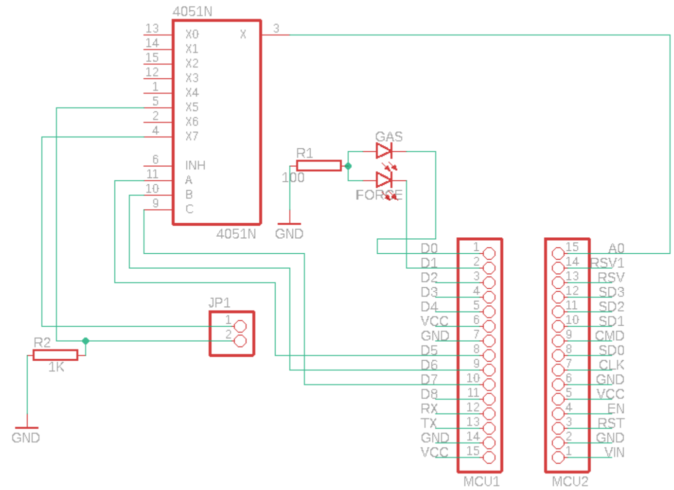

Fig. 3. Circuit Diagram of Proposed System

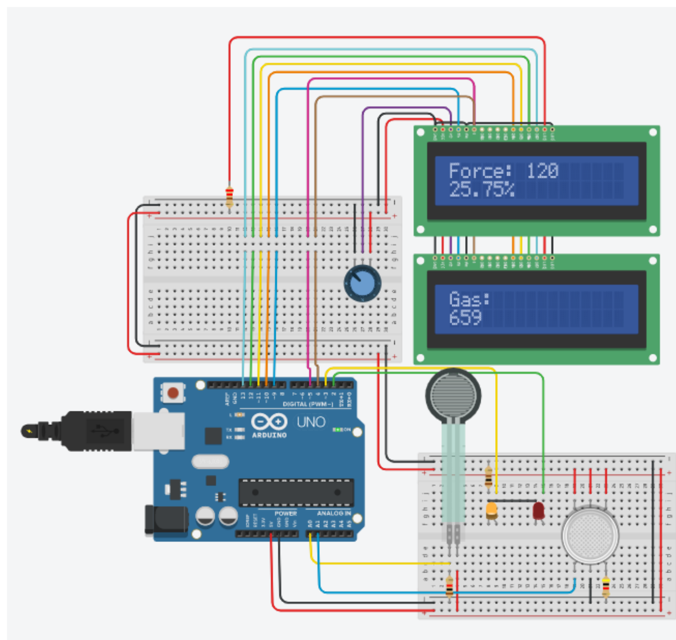

Fig. 4. Schematic of Proposed System

Fig. 4 describes the detail component integration and the overall working of the proposed system Fig. 4 shows the simulation of the project that has been performed on Autodesk TinkerCAD®. Here 2 LCD monitors are used as wireless transmission cannot be simulated. As seen the readings of the force and gas Sensor are shown on the user device (LCD Display in this case) and as the gas has crossed the soft threshold of 470 PPM. The Yellow LED has been lit up to warn the user of some abnormal Gas concentrations in the surrounding atmosphere.

After completing the Hardware assembly the proposed system uses a certain set of softwares to program the assembled hardware. The Visual Studio Code IDE was used in order to program the Flutter application with the Flutter DSK which is based on the Dart programming language. The PlatformIO IDE which fits on top of the VS Code IDE was used to program the Node MCU. Autodesk Eagle was used to used to create the PCB schematic which will hold all the hardware components for the proposed system.

IV. SYSTEM IMPLEMENTATION

The project uses a mobile application as the means of connecting the device data and the end user. All the data collected from the sensors is uploaded to the local network in the form of a JavaScript Object Notation (JSON) format. This is useful as the mobile application then collects the data and directly processes it into useful information and displays it to the users. This exact process is explained in detail in the paper below

The application is segregated into 2 main parts

1) Sensor readings
2) Network Configuration

Sensor Readings : This section displays the collected sensor data to the user. The sensor data is displayed in the format of percentage and a graph which is refreshed at 200 ms for getting the new data.

Network Configuration : This is to ensure that the ESP8266 WiFi module is connected to the application and correctly configured.

In any application where the data needs to be shared from one screen to another a concept of state management is used. [19] This is needed in order to share data between the various screens or pages of the application. Flutter has several state management systems including redux framework and BLoC architecture [20]. In this application BLoC architecture is used.

BLoC abbreviates to Business Logic of Components. This method is recommended in the official Flutter documentation by the Flutter's Development Team. The BLoC state management system is similar to the M-V-VM (Model View ViewModel) state management system [21], but uses various streams in order to achieve the same effect. The concept of BLoC is to have a corresponding effect for each state inside the application, this is better explained in the figure below.

Fig. 5 explains the working of BLoC Architecture

Like displayed in Fig. 5 the UI Screen loads an event on the event stream which is then carried on to the BLoC. According to this event package the BLoC interacts with the repositories and emits a stream of states on different stages of the interaction. This state is then again carried out to the UI Screen and required changes are made to indicate to the user some processes are going on in the backend. This methodology has several advantages.

Using the BLoC State management has several Advantages like State of application can be known in any point of time which is particularly useful in the cases which have constant data fetching requirements as the proposed system. From a developer's perspective the testing of the application is easily possible if the developer uses the BLoC Architecture which also greatly increases the code efficiency and reusability of the code compared to older architecture formats. Furthermore, data driven decisions can be made by recording the user behavior which helps in increasing the user comfort and make a more personalized user experience for the user.

The application uses two cubits in order to manage its state. The main difference between a cubit and a bloc is that the cubits don't use event streams but send the states on a stream. Meaning only the response of the cubit is a stream and not the input.

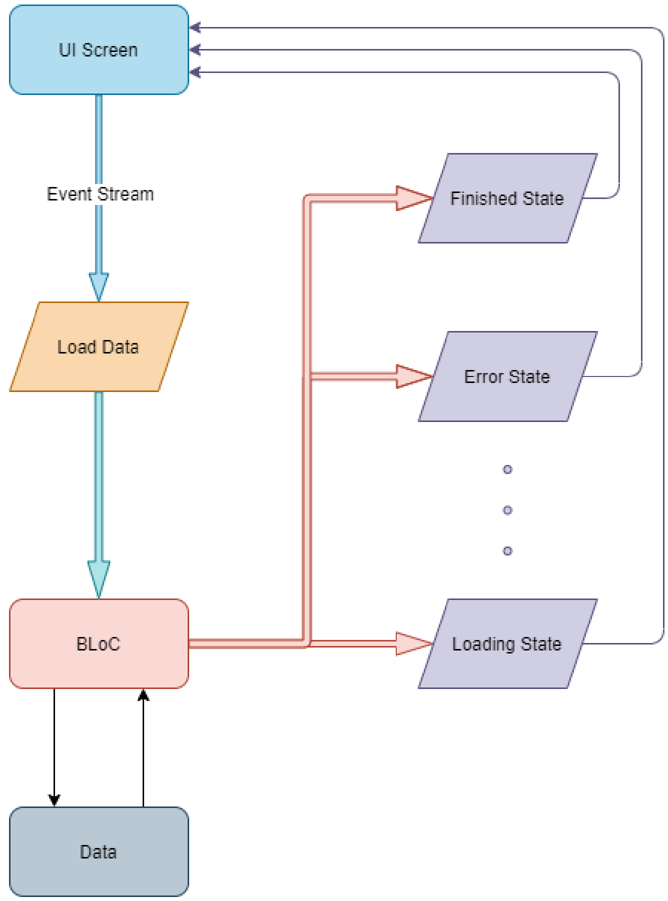

Fig. 5. BLoC Workflow

Fig. 6 explains applications workflow:

The first cubit is to get the sensor readings from the API endpoint generated on the network IP generated by the ESP8266 WiFi module. This cubit emits 3 states. The initial state sets the force sensor and the gas sensor readings to zero and continues to send requests to the API endpoint. The next states are determined by the response emitted by the repositories. If the response is an error response code i.e. anything other than the 200 HTTP response code the cubit emits the Error state and notifies the user some error has occurred, else the force sensor and gas sensor values are updated giving the user the correct values of the same. The new requests are made in an interval of 200 milliseconds, thus the user gets the data in realtime. The repositories emit two kinds of data, percentage and actual values of the sensors, the percentage is displayed directly to the user and the actual values are used to map out a graph of the sensor readings, this gives a better understanding of the situation to the user.

A similar approach can be observed in the network configuration cubit where the cubit emits three states the same as the former. These emitted states are then caught by the UI

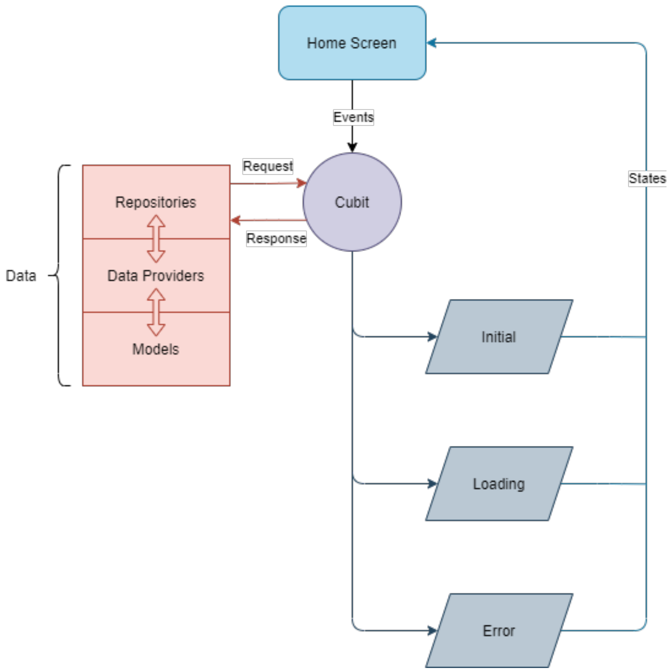

Fig. 6. System BLoC Workflow

components and then those components are rerendered to give the user the necessary information.

V. Results and Discussion

Monitoring the behavior of the system in the real life scenario is the right way to estimate the accuracy and reliability. To check the functionalities of the proposed system, the team conducted two experiments, where in the first experiment force was applied to the force sensor and in the second experiment polluted the air with certain carbon compounds were released in the vicinity of the MQ-135 gas sensor. In both these experiments, the results indicated the actual behavior of the sensor with the change in its atmosphere. When Force is applied, the user application shows a change in the percentage indicating the capacity of the LPG cylinder filled. The presence and detection of the carbon compounds by the gas sensor sends this message to the user application showing an increment in the percentage of the gas leakage detected. An increase in this percentage would indicate an increase in the excess gas detected. All the conducts of the environment perceived by the two sensors can be visualized in the form of two graphs. Thus, the employed system can successfully fulfill the objectives previously defined.

These are some of the graphs captured by the reading of sensor while testing the proposed system. Fig. 8 is a graph of Force sensor which depicts the gradual decrease in the income of the force indicating that the gas cylinder is becoming empty as the time progresses.

The gas sensor (MQ-135) is used to find gas leaks in cylinders or pipelines. The measurements obtained from the gas sensor are shown in Fig. 9. The MQ-135 gas sensor's extremely high precision means that even the smallest change in the air around it can change results. The MQ-135 gas sensor was chosen because it can identify methane (CH_4), carbon dioxide (CO_2), and other exhaust gases present in the atmosphere. Therefore, as soon as it detected any exhaust gas, the number began to change. The graph's high, sharp edges suggest that there is an abnormally significant gas leak, which has to be addressed.

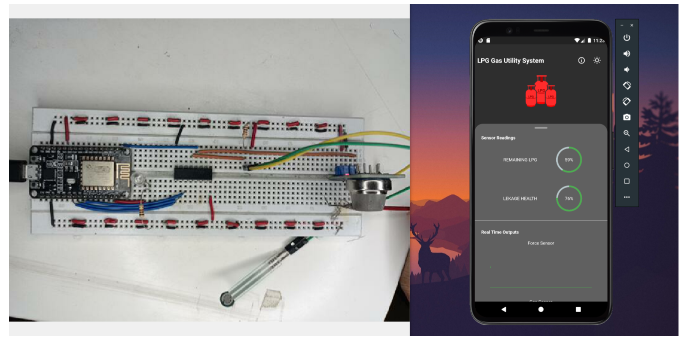

Fig. 7. Output of the Proposed System

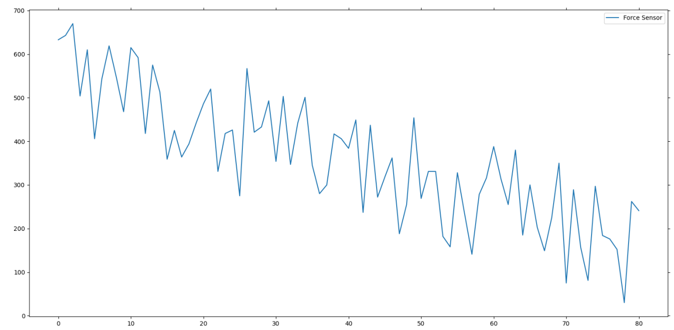

Fig. 8. Force Sensor Readings

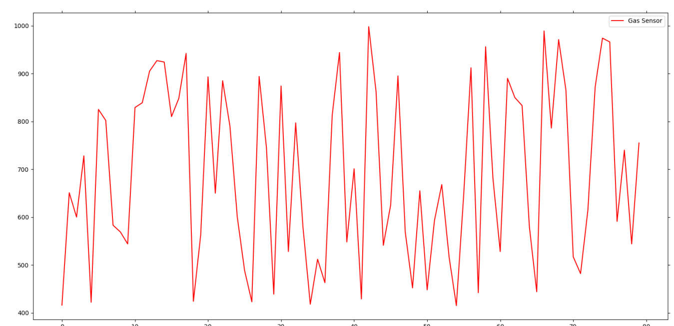

Fig. 9. Gas Sensor Readings

Fig. 10 contrasts the readings from the gas sensor with the force sensor. The weight of the cylinder continues to decrease as the amount of leakage in the cylinder or pipeline increases. As a result, the force sensor's value drops. One finding from the graph is that the readings from the force and gas sensors are inversely related to one another. Figure 10 combines the graphs from the force and gas sensors so that the viewer may quickly see both spectra of the features that the proposed system is monitoring.

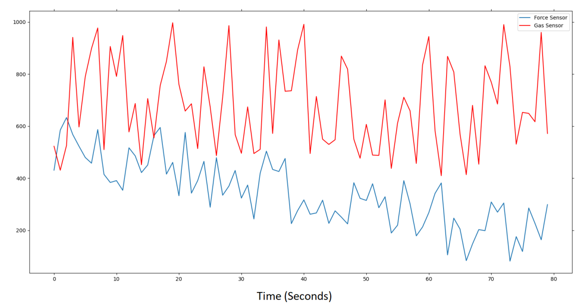

Fig. 10. Force and Gas Sensor Readings

In a cylinder, LPG is liquid until it reaches a pressure-sensitive region at the top, where it turns into vapour (gas state). As the cylinder is utilized for generate energy, the pressure inside of it continuously drops. Fig. 11 elaborates the readings taken while the system was tested on a cylinder. As seen in the illustration, the pressure in the cylinder continues to drop as the number of days rises, showing that gas is being consumed.

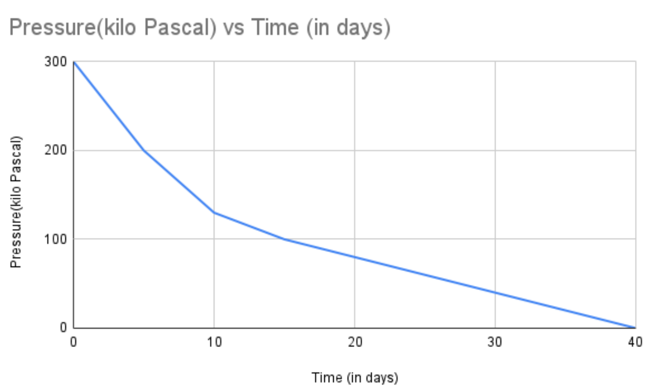

Fig. 11. Pressure vs Time

The system's real implementation is depicted in Fig. 12. This paper tested the system once it was implemented and found it to be functional.

VI. Limitations

Every created system comes with some advantages over others as well as some shortcomings. As the project is a basic need of any household and industrial area, it has a huge scope of improvement in many aspects as,

1) Requires extra sensors to detect the leakage at different positions.
2) Unable to handle gas leakage emergencies.
3) Requires stable Wi-Fi connection for communication.
4) Bluetooth can be used to send SMS.

Fig. 12. Physical Setup of the Proposed System

VII. Future Scope

Limitations are anticipated to be overcome in the future. If there is a long gas flow, it indicates that we need a long pipeline, which increases the likelihood that gas will leak at various locations if the pipeline is not well maintained. Therefore, more sensors are needed in this situation.The DC geared motor may be incorporated into a system. As a result, in the event of a significant gas leak, the cylinder's regulator can be instantly switched off. The system is unable to upload the data regarding the cylinder since some areas lack Wi-Fi or internet access. So bluetooth can be used for communication instead of Wi-Fi or the internet.

VIII. Conclusion

The most common problem in many households of sudden shortage of LPG gas which is the most essential component of the kitchen has been there for decades, but no one has tried to fix it. This system has a great effect not only in the households but also on the larger scale, like hotels, restaurants and even mobile kitchens. Even though the system's main focus is to bring an amount of comfort to the homes it also provides a sense of safety. As a constant gas leakage monitoring is in place the system has a way of giving the user a sense of comfort.

The system is based on Node MCU and thus makes all of its communications through the ESP8266 WiFi module. The gas leakage the system can also have some additional comfort features like automatic gas booking and bluetooth SMS service.

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