Gas Leakage and Utilization Monitoring of LPG Cylinders Using Machine Learning and the Internet of Things (IOT)

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Abstract: **The use of LPG cylinders is progressively rising in India, with consumers including households and commercial establishments such as hotels, some of which also employ them for lighting purposes. Two issues may arise when utilising an LPG cylinder: leakages and monitoring gas use. A machine learning and IOT-based monitoring system has been designed to address the aforementioned issues. The consumer is unaware of the gas consumption rate for different applications and the depletion timeline of the cylinder's contents. This paper presents a machine learning and IOT-based system that monitors gas consumption past, present and future demand. To estimate the future demand by using PINN (Physics-Informed Neural Networks) algorithm based on the previous consumption history and present consumption for different gas consumption applications and notifies the consumer via SMS over a GSM-5G module. When the gas level falls below the threshold value, the system will send an alarm message to the user. A sensor known as a load cell determines the quantity of gas in the cylinder. Utilising this machine learning IOT-based monitoring system, we can mitigate gas leakage, prevent explosions, and monitor real-time gas usage, which facilitates efficient gas refills.**

Key word: **PINN (Physics-Informed Neural Networks), LPG(Liquefied Petroleum Gas), SMS(Short Message Service), GSM (Global System for Mobile Communications)**

1. INTRODUCTION

LPG is used for daily utilization due to its cost-effectiveness and lower expense. The primary use of chlorofluorocarbons which damage the ozone layer. The composition of LPG is made up of butane (55%) and propane (45%) with some traces of isopentane and olefins. The LPG is stored in the form of liquid inside the cylinder. LPG is lighter than water. The LPG may be available from 4kgs to 450kgs. Due to the increasing demand for LPG, users must prebook their LPG cylinder at least one month in advance or they must place an order only after the gas level is depleted. So, we suggest an effective way to monitor the quantity of LPG in the cylinder, hence we prevent prebooking and late booking of gas cylinders.

2. MAIN HARDWARE COMPONENTS

- Arduino uno

The choice of Arduino uno for this project is because of its cost-effectiveness and the abundance of troubleshooting resources accessible in the open-source community. It works with most shields and modules. It is user-friendly and suitable for battery powered projects.

- MQ6 Gas Sensor:

The MQ6 gas sensor is a type of semiconductor gas sensor that detects the presence of gases such as LPG (Liquefied Petroleum Gas), propane, and butane.

- Load cell with HX711:

Load cell measures the quantity of gas in the cylinder. With the help of HX711 amplifier the output which is weight signal taken from the load cell converts in to digital data.

3. PHYSICS INFORMED NEURAL NETWORKS ALGORITHM (PINN)

PINNs are a type of neural network that combines the power of deep learning with the principles of physics. It consists of neural network that takes input data and predicts the output. PINNs can be used to predict the gas flow rate and gas leaks. PINNs can provide more accurate predictions of gas

flow rate and pressure and detect leaks more effectively. It can be integrated with IOT sensors to collect real-time data on gas flow.

3.1 Data required training the neural network model
- Previous gas usage patrons
- Family members data like food habits and daily routines of food
- Environment based gas usage

3.2 Integration of physical models
- To get actual gas consumption
- Comparison of estimated and actual data

3.3 Equipping the Model
- The neural network picks on prior trends.
- Guarantees significant results by adjusting settings under physics-based limitations.

3.4 Prediction Phase
- Using trained PINNs, forecast future gas demand.
- Predict how many days gas will last before needing a refill.
- Identify unexpected variations (e.g., a surge in gas consumption due to a family gathering).

4. PROPOSED SYSTEM

The system consists of MQ6 gas sensor, Arduino, an IOT platform and an alert system. In this system gas leak detection, monitoring the gas usage and prediction usage of the gas and remaining gas in the cylinder is calculated by using PINN algorithm and notifications will send to the consumer through alert system. Load sensor detects gas level and sends data to Arduino, which processes the data and commands GSM module to send alert through SMS.in figure 4.1 show the details working of the proposed system.

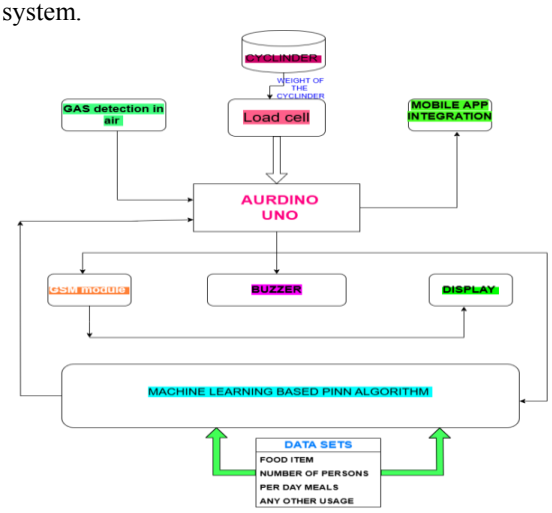


Figure: 4. 1: whole process for monitoring LPG cylinder gas leaks and usage

Load cell sends the data to Arduino. Arduino then sends the gas level data to the GSM. If the gas level falls below the threshold value, then GSM sends an alert to the user through SMS. This real time monitoring and alert system help prevent accidents caused by gas leakages.

4.1 WORKING PROCEDURE

Case 1: Gas leakage detection & alarm system process

In figure 4.2 flowchart clearly explain the how the MQ6 gas sensor detects gas in the air and transmits that signal to Arduino which triggers the buzzer and also sends SMS through GSM module. Gas sensor continuously, keeps monitoring. After the catalytic combustion reaction Arduino receives a change in output voltage, which activates buzzer.

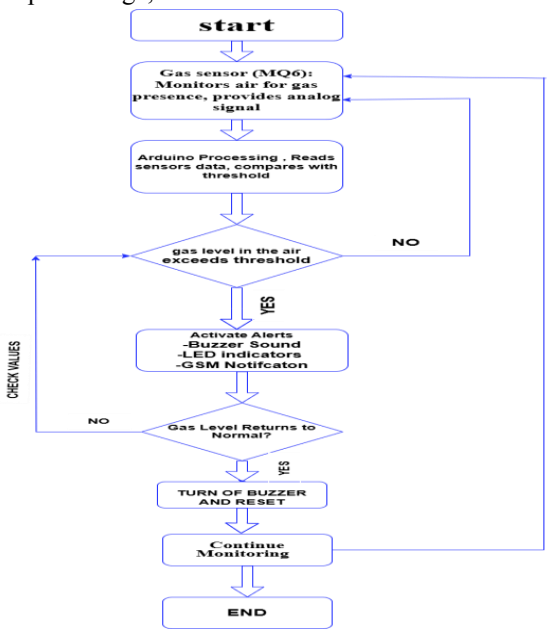


Figure: 4.2: Flowchart of Gas Leakage Detection & Alarm System Process

Case 2: Working of load cell for gas level monitoring

The load cell continuously measures gas level in the cylinder. It means when the weight decreases gas level also decreases. HX711 amplifier converts weight signal in to digital signal. The amplified signal is delivered to Arduino and it is below the threshold value it sends alert and gas level is displayed on LCD.

Case 3: Working of PINN algorithm with Arduino board

Arduino collects real-time values receives from gas sensor, load cell and sends structured data to the PINN model. It also reads past usage records, number of family members and meal types. Then if any gas leakage it alerts us through buzzer and an SMS also sends to user mobile number.

5. RESULTS AND DISCUSSION

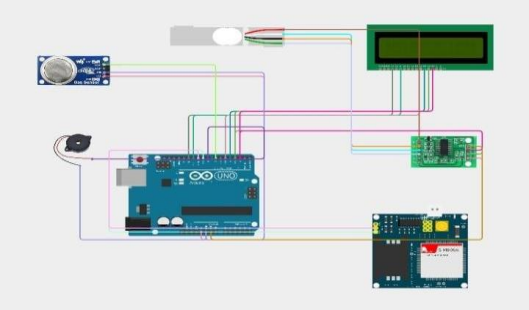


Figure: 5.1:circuit diagram of the proposed method

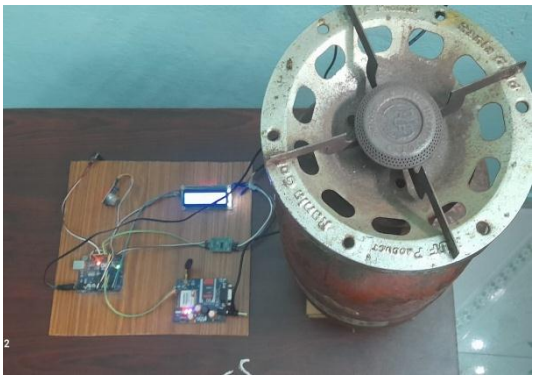


Figure: 5.2: while using the LPG Monitoring System

In figure 5.1 shows the overall circuit diagram of the proposed LPG monitoring system .figure 5.2 is while testing the LPG monitoring system in real time .If the gas level in the cylinder is up to certain level or the gas level is full it will not give any alert. As per the figure 5.3 cylinder holds 4 to 5 kgs.

Fig :5.3: With LPG cylinder

The GSM module gives alert when the gas level value is below the threshold value or when the gas level is empty. Otherwise, it will not send any SMS. Here, in the figure 5.4 there is no gas in the cylinder that means it is empty. Hence it sends us alert through GSM via SMS which is clearly seen in figure 5.5.

Fig 5.4: Without LPG cylinder

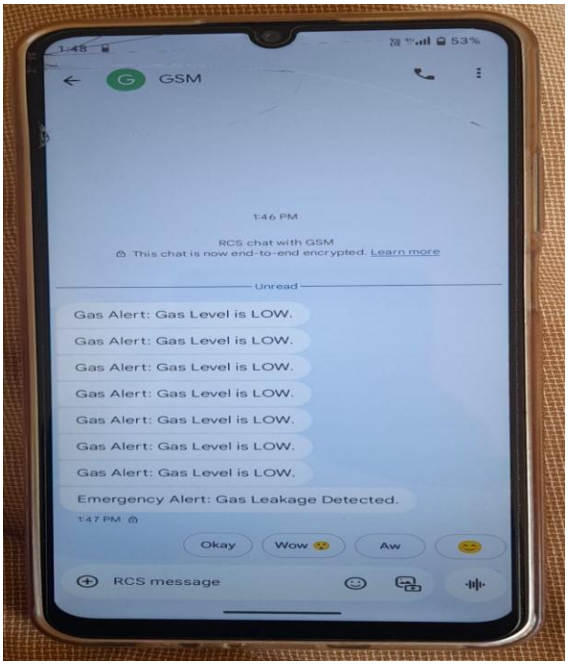


Figure: 5.4: notification to the LPG consumer from the proposed LPG monitoring system

5.2: Software Results:

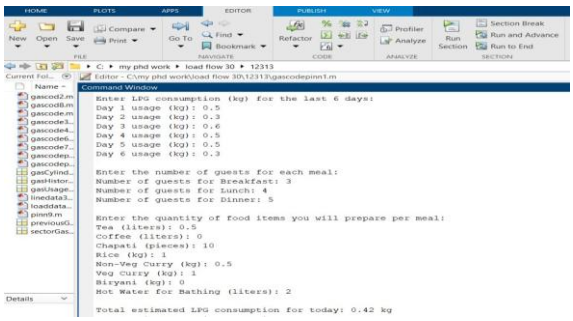


Fig 5.5: PINN algorithm-based result to estimate gas utilization based on food and number of members

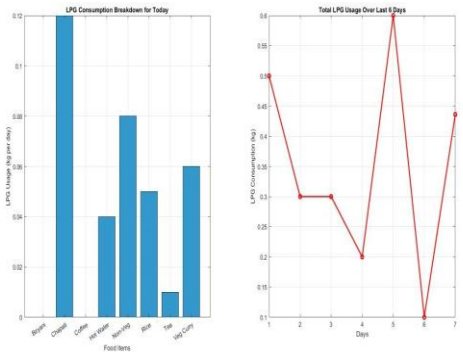
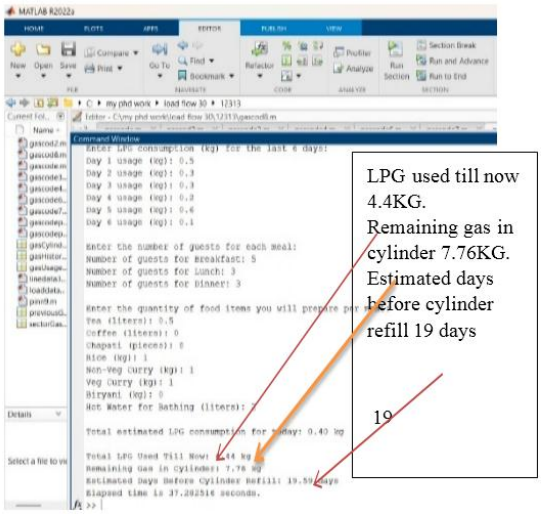


Fig 5.6: Food item wise gas utilization per day and last 6 days gas utilization

The figure 5.5 and 5.6 shows the result of PINN based LPG cylinder utilization monitoring based on the food cooking per day and number of food consumers per meal. Different types of food items are given to the training sets, and item-wise utilization is estimated by the PINN algorithm, which results are shown in figure and it will estimate the LPG utilization per day and past 6 days data, and finally it will give the remaining gas in the cylinder.



6. CONCLUSION

Hence, cost effective gas level detection and alert system using machine learning, using PINN algorithm is proposed and implemented successfully. In conclusion, gas level detection and alert system using IOT and machine learning algorithm is a cutting-edge solution. it revolutionizes the way gas supplies are managed, making it more efficient and reliable. The system's ability to detect gas levels accurately is unparalleled. It reduces manual errors and enhances operational efficiency. The system's real time monitoring and alerts ensure timely refills and minimize gas shortages. The system's scalability and flexibility make it suitable for various industries and applications.

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