IoT Based LPG Cylinder Monitoring System

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Abstract— Liquefied Petroleum Gas (LPG) is widely used in households, but the consumer is unaware of the daily rate of consumption and the time frame when he/she needs to book a refill. In this paper, we present an Internet of Things (IoT) based system which monitors different aspects related to LPG cylinder, and thereby keeps the consumer updated via a mobile application. The algorithm developed predicts the average number of days for which the LPG cylinder will last, depending upon the consumption pattern of the consumer. Additional features include displaying the percentage of LPG consumed, the real-time weight of the cylinder and one-click refill booking via mobile application. The safety feature is inherent part of this home automation system, as when gas leakage is detected it alerts the consumer via mobile application and in-built buzzer. Simultaneously, it turns off the gas regulator knob to prevent further leakages from the source. The system is designed such that it can be used as an LPG cylinder stand.

Keywords- Home automation, IoT (Internet of Things), LPG cylinder monitoring, LPG leakage detection, Arduino.

I. INTRODUCTION

Liquefied Petroleum Gas (LPG) is a leading source of energy used for cooking and heating at residential and commercial places worldwide. It is an economical and clean source of energy compared to other sources of energy like firewood, coal etc. It is also used as a source of energy in industry and fueling various vehicles. The two major types of gas used are natural gas and LPG.

Even though LPG is widely used and is an integral part of a household, yet the consumers are unaware of the daily rate of consumption and the time frame when he/she needs to book a refill. This affects the consumers when the LPG cylinder is empty unexpectedly. And at times it impacts the supply chain due to sudden spikes in demand. Additionally, the usage of LPG requires certain guidelines to be followed, to ensure safety. According to the statistics provided by The Ministry of Petroleum and Natural Gas, Government of India the total number of accidental deaths by cooking over gas cylinder in India 835 in 2018-19 (Apr – Dec) [1]. There exists a potential danger of gas leakages due to wear and tear of pipe connecting the LPG cylinder, human negligence, defective gas stove etc. This poses a great danger due to the highly flammable and explosive nature of the gas.

The aim of the proposed system in this paper is to overcome the above-mentioned problems with an IoT (Internet of Things) based system which will monitor different aspects related to the LPG cylinder and convey it to the consumer. Our proposed system improvises on the existing work [2], [3], [4] by introducing a gas regulator control mechanism and a mobile-based application. The gas regulator automatically closes in case of a gas leakage being detected and the application benefits in real-time monitoring of the gas weight.

The system discussed above, adopts a consumer-centric approach to provide various data pertaining to LPG's daily usage, based on this a rough estimate about the number of days LPG cylinder will last is provided. This will enable the consumer to plan their consumption and also order a refill well in advance. It will also help the entities involved in the supply chain of cylinder distribution to understand the demand-supply of cylinders over different geographical regions at different times.

II. SYSTEM BLOCKS

Home automation basically gives consumer the access to control the devices, without having physical proximity. This is possible by development of mobile technology and IoT platform. IoT is the system of interconnected and interrelated mechanical, digital, computing devices, objects or people. The 'thing' in IoT can be any object that has the ability to collect and transfer data over computer network without any human intervention.

This whole system consists of the following main components:

- Arduino Uno
- Load cell
- Analog to Digital Converter (HX711)
- LCD screen
- Inter-Integrated Circuit (I^2C)
- Gas Sensor (MQ-6)
- Servo motor
- Logic – Level Converter (LLC)
- Wi-Fi Module (ESP 8266)

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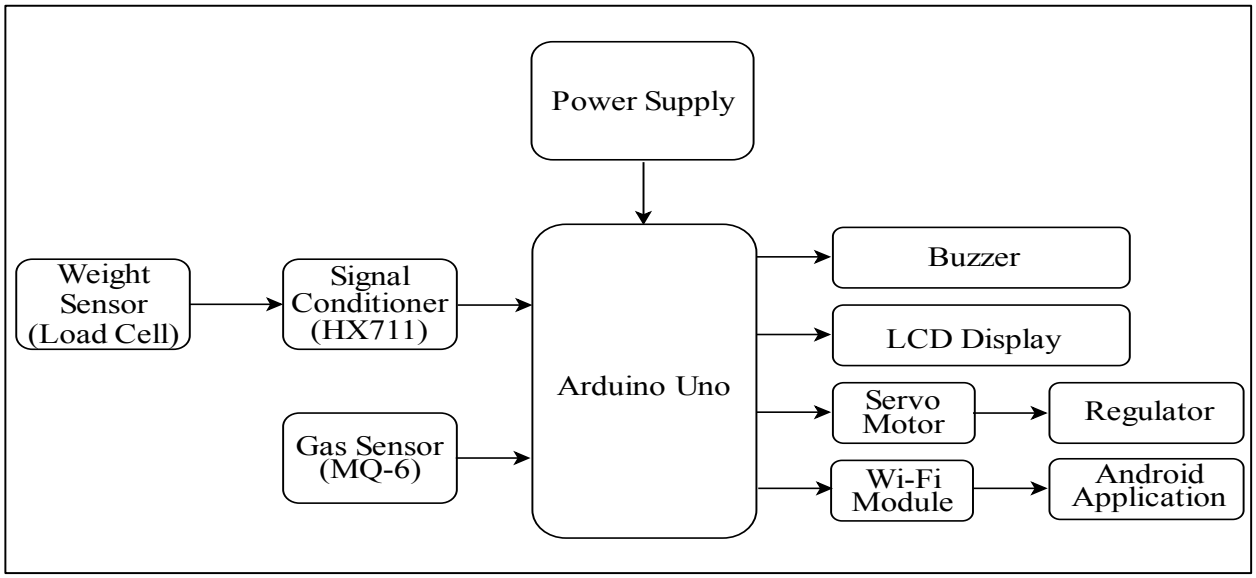

Figure 1. Block Diagram of the proposed system

The block diagram displaying the overall interconnections between different components is represented in Figure 1.

The **Arduino Uno** [5] is a member of the Arduino family, a microcontroller board based on the ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP (In Circuit Serial Programming) header, and a reset button. The versatile functionality of Arduino is the reason why it was chosen for this system.

This system consists of a load cell which would be connected with the Analog to Digital Converter (ADC). **Load cell** acts as a weight sensor with a capacity of 40kg. A load cell is a transducer that is used to convert a force into measurable electrical signal. Weight of the cylinder is measured by placing it on the arrangement which consists of four strain gauges in a Wheatstone Bridge configuration. Wheatstone bridge outputs voltage which is due to the applied pressure or force of the cylinder. The output of the load cell is in the analog form, but controller accepts only digital form. This requires an **Analog to Digital Converter (ADC)** [6]. Whenever a cylinder is kept on the stand the load cell measures the weight of the cylinder and sends an analog signal to ADC. This analog signal is in the form of millivolts which is amplified by ADC. Now, this signal is converted to digital signal and sent to the Arduino Uno. The Arduino displays the real time weight of the LPG on the LCD panel.

Liquid Crystal Display (**LCD**) screen is an electronic display. A 16x2 LCD display used here is a very basic module and is very commonly used in various devices and circuits. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD screen is used to display the weight of the gas and the warning messages.

The LCD utilizes an **I^2C** interface which means that less pins would be required to interface the LCD. The I^2C 16x2 LCD module is a 2 line by 16-character display interfaced to an I^2C daughter board. The I^2C interface only requires 2 data connections, +5 Voltage (V_{DC}) and GND to operate. Its backlight and contrast are adjusted by potentiometer.

A **MQ-6** [7] gas sensor is used to detect the leakage in the LPG. This is connected with the Arduino and it sends a signal whenever a gas leakage is detected and in turn the Arduino sends a signal to the buzzer which indicates that there has been a leakage. Though, LPG is odorless but to detect its leakage a chemical agent is added to it called, Ethyl Mercaptan [8].

In addition to this, the Arduino also sends a signal to the **servo motor** which is connected to the regulator. This servo motor turns the regulator knob off, in case of leakage or if initiated by user. A **servo motor** is an electrical device which can provide torque to an object with great precision. It is just made up of simple motor which runs the through **servo mechanism.**

Next is the Wi-Fi module, **ESP8266** which enables data to be sent over internet. The real time weight of the LPG cylinder is sent to the mobile application by internet after port forwarding the Wi-Fi module or through home Wi-Fi network. ESP8266 (Wi-Fi module) is a self-contained SoC (System on a Chip) with integrated TCP/IP protocol that gives any microcontroller access to a Wi-Fi network.

Later, a bi-directional logic level converter (**LLC**) [9] is used which converts voltage levels from 5 V to 3 V and vice versa. This is used in the system because Wi-Fi module works on a 3.3 V, 80 mA input supply.

III. ALGORITHM

The open source **Arduino software** (IDE), version 1.8.6 was used for writing and uploading code to the Arduino Uno board. The basic algorithm which was used to program the system is given below:

INITIALIZE		
	The output and clock pins of Load cell and Gas Sensor Calibrating the Load cell A "COUNTER" set to 0 Setting up the LCD with: "LPG MONITORING SYSTEM"	
START LOOP		
	IF Weight < 10KG THEN "PUT THE LPG CYLINDER" COUNTER=0 IF Weight > 15KG && COUNTER==0 THEN "WEIGHT CALIBRATED" and "WEIGHT = (current LPG weight)" COUNTER INCREMENT BY 1 IF Weight < 10.65KG && COUNTER==1 THEN "3/4th USED" COUNTER INCREMENT BY 1 IF Weight < 7.1KG && COUNTER==2 THEN "HALF USED" and "1st WARNING -- BOOK YOUR LPG" COUNTER INCREMENT BY 1 IF Weight < 3.55KG && COUNTER==3 THEN "BOOK YOUR LPG ASAP" and "EMERGENCY" COUNTER INCREMENT BY 1	
END LOOP		
IF PPM > 30 THEN "GAS LEAKAGE DETECTED" and BUZZER-SOUND and Switch off Regulator		
	START LOOP	
		IF PPM less than 25 THEN BUZZER OFF BREAK
	END LOOP	

IV. MOBILE APPLICATION

To develop the mobile application, **Android Studio**, version 3.3 was used. Android Studio is the official IDE for android development, and includes necessary modules and libraries that is needed to build an Android application.

The following segments would be the part of the mobile application:

- On the first login, the consumer would be prompted to give permission to send messages and enter their personal details with their location. After collecting this information, the IVRS (Interactive Voice Response System) number of that particular city would be selected automatically. Eventually, the consumer would be asked to enter their CONSUMER-ID.
- The next segment would contain the calibrated weight of the cylinder which would be fetched from the Wi-Fi module via internet (using port-forwarding) or using home Wi-Fi network.
- Now, the consumer can monitor the weight of the LPG cylinder anytime from anywhere as the application is setup, which was first and most important concern.
- With every warning message, a notification is popped up in the consumer's mobile. When the LPG cylinder has been consumed by over 50%, the booking option would be available to the consumer. By clicking, BOOK NOW, a message would be sent at the IVRS Number and a refill request would be submitted (standard carrier charges may apply).
- The data obtained from the server is saved in the internal memory of the consumer's mobile and after at least 3 days of initial usage of the LPG cylinder, the average consumption of the consumer is calculated and displayed in the mobile application.
- Also, the number of days left for the LPG to get over is calculated on the basis of daily average consumption.

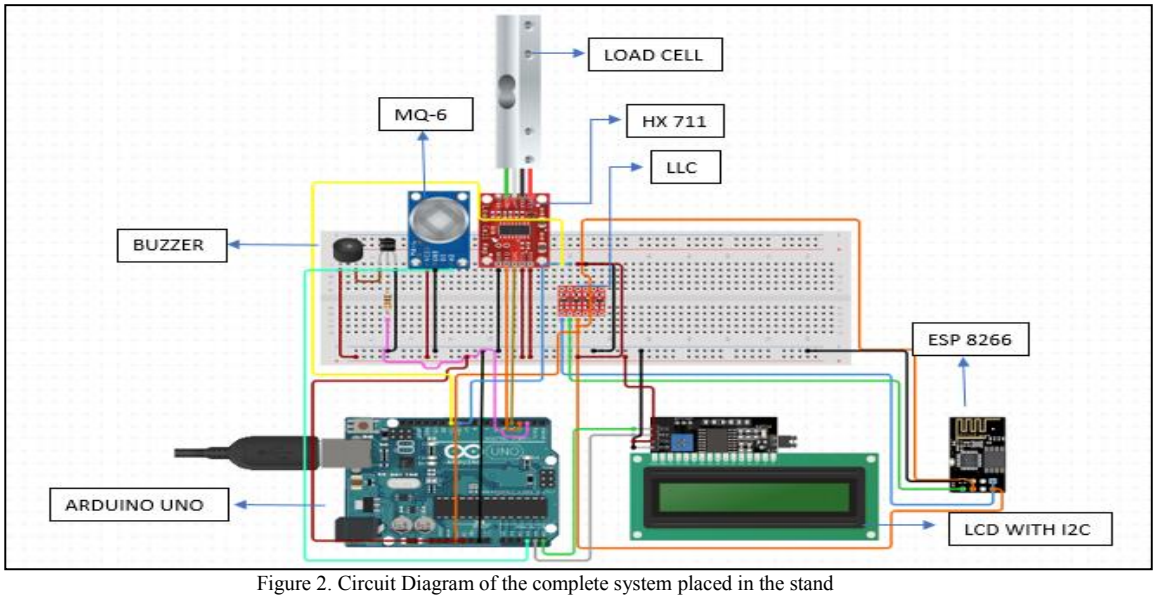

Figure 2. Circuit Diagram of the complete system placed in the stand

- Through this mobile application the consumers can switch off the regulator from anywhere and anytime. But when a gas leakage would be detected the regulator would be switched off automatically in the back-end as shown in the Figure 3, Gas Regulator Control System.

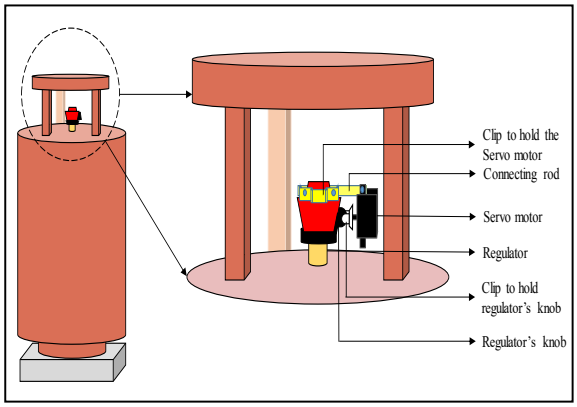

Figure 3. Gas Regulator Control System

V. WORKING

For generating test cases and demonstration, it was not practical to use LPG cylinder in real time, due to cost and time considerations. Hence, a cylindrical container was used, which served as scaled down version of a LPG cylinder. Instead of LPG, this container was filled with water. This facilitated ease of flow control and thereby, rapid change in weight for calibration and testing of the system. An outlet pipe was connected to the cylinder and when the pipe was opened, water was allowed to flow out, which simulated the consumption of LPG. As the water level decreased from the container, the notifications were accordingly displayed on the LCD panel. The same notifications were displayed on the mobile application.

To demonstrate gas leakage, as the gas sensor is sensitive to both butane and LPG, cigarette lighters were used as they contain butane. The gas was made to leak from the lighter by extinguishing the flame. When the sensor detected a leakage, an alarm was raised, thereby switching off the regulator knob with the help of servo motor. In addition to this, a warning signal was also sent to the mobile application.

The approximate cost for the whole setup amounted to INR 1900, which could be further reduced if the system is integrated on a printed circuit board. This demonstrates the cost effectiveness of the system.

VI. CONCLUSION

In this paper, the idea proposed would be another step towards home automation. This system would considerably reduce human intervention in the booking or monitoring of the LPG cylinder and hence will save much time or the hastiness in booking the LPG cylinder. Additionally, it will also ensure human safety by preventing accidents due to leakage. With appropriate configuration this system can also be scaled for its use in industries where heavy pipelines and cylinders are used. The proposed system when successfully implemented can also be used in mines where gas sensors will detect leakage of toxic gases and can send a signal for the emergency evacuation of workers.

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