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REVIEW ARTICLE

ENGINEERING

IoT Based LPG Monitoring and Controlling System - A Case Study

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Abstract

Liquefied Petroleum Gas (LPG) is a primary source of fuel, particularly in households. LPG leakage causes a variety of incidents, resulting in both financial damage and human casualties. Because of the rising demand for LPG, the possibility of LPG leakage is very high. LPG leakage can occur from a variety of sources, including the burner, pipe, and regulator. One of its preventative approaches for preventing gas leakage incidents to install a kit which can identify the gas leakage in certain regions. There are several devices currently in market, allowing users to frequently monitor their LPG consumption and receive notifications when leakage occurs. In this study, we examined several LPG leakage detectors and detection methodologies available. Accuracy is also vital while detecting leakage. As a result, in this paper, we also explored various approaches or pieces of hardware that may be utilized to boost accuracy.

Keywords: *Arduino UNO, Gas Sensor, GSM Module, LED light, LCD, Buzzer, Weight Sensors*

1 Introduction

Liquefied Petroleum Gas (LPG) is an odourless gas. The main chemical used to provide odor to the odourless LPG is ethyl Mercaptan(1). It is a type of fuel that has mostly transformed traditional fuel systems in the domestic and industrial sectors. Even though it is one of the fuels that is used the most frequently, it has an explosive range relatively high i.e., from 1.8 percent to 9.5 percent in the air. Based on the weight of the LPG in the cylinder, it is divided into three categories: household, commercial, and industrial. The domestic cylinder carries 14.2 kg of LPG whereas commercial and industrial cylinders hold 19 and 35 kg of LPG, respectively(1; 2) . LPG is mostly used for cooking in homes. LPG leakage can occur due to several issues, including the burner, pipe, and regulator(3). When leakage occurs, the released gases may create an explosion. Gas leaks cause a variety of accidents that result in both material damage and human loss. The number of deaths caused by gas cylinder explosions has increased in recent years. The Bhopal gas disaster is happened because of the gas leakage. One of its preventative approaches for preventing gas leakage incidents is to install a gas leakage detecting kit in certain regions(4). As a result, LPG leakage detection has grown in popularity in recent years, particularly in the sector of safety. A traditional gas leakage system employs on-site alarms to intimate about the leakage. The drawback of the standard leakage detection technique is that it is useless when there is no user present. Therefore, a system is necessary to locate the leakage and communicate the information to the user. Not only is it important to identify gas leakage, but it is also necessary to prevent leakage to prevent damage. A leakage detection system that sends an alert by phone or SMS and can stop the gas supply automatically will be more effective(5). In this study, we will examine several LPG leakage detectors and their detection methodologies available on the market. Accuracy is also vital while detecting leakage. As a result, in this work, we will also explore various approaches or pieces of hardware that may be utilized to boost accuracy. The remaining work is structured as follows. Section 1.1 includes a brief description of the existing systems. Section 2 includes the required hardware details. Conclusion is highlighted in section 3.

Table 1: LPG Leakage Detection Systems with Existing Features

Sl. No.	Features of Existing Devices								Ref
	Leakage Detection	Control Gas Flow	Alarm/ Buzzer	SMS/ Call	Weight Monitoring/ Gas Meter	LCD Display	Gas Flow Rate	Gas Booking	
1	Yes	Yes	Yes	Yes	No	No	No	No	(17)
2	No	No	No	No	Yes	Yes	Yes	No	(18)
3	Yes	Yes	No	No	No	No	Yes	No	(19)
4	No	No	No	Yes	Yes	No	No	No	(20)
5	No	No	No	No	Yes	No	No	Yes	(21)
6	Yes	No	No	Yes	Yes	No	No	Yes	(22)

1.1 Description of Some Existing Systems

There have been several studies conducted in the past on LPG monitoring and leakage detection systems. An overview of the existing systems is provided in this section. Additionally,Table 1 also highlights some products with some of their existing features. In(6), an automatic cylinder booking and LPG monitoring system based on WSN was suggested by the authors. The customers will be alerted by an alarm if the system finds any LPG leaks while it is monitoring the leaking of LPG. A continual motoring of the cylinder's weight is also possible with this technique. A warning is given to the user and a booking request is sent to the distributor if the weight of the cylinder drops below the minimal threshold. By using sensors this device identifies the leakage. An exhaust fan is used to controls gas within the area. Continuous monitoring of the cylinder's LPG level is also included. In(7) the authors mentioned the possible use of electrodes to improve air quality. This article uses the MQ-3-based sensors to detect the air quality of an area. In comparison to the tested commercial equipment, the sensor responds more quickly. In(8), the authors suggested a single computer-based smart home security alarm and remote-control systems to detect and prevent leakage. An 89C51 computer chip is incorporated in this system to automatically control audio alarms and remote-control leakage. An alert mesage can be sent out by the system while dialling the police department. Additionally, an alarm with the address of the alarm's origin may be displayed. Remote phone management of this sophisticated security system is possible. In such application, particular type of sensor is used to measure the LPG cylinder's weight. The ARM7 controller receives the load cell output after it has been signal-conditioned. The controller responds appropriately to input and displays the LPG level on the display unit. When the LPG level falls below a certain threshold, an SMS is sent out requesting for cylinder reservations. In(9), the authors introduce an autonomous robot based on Android. A tiny mobile robot that can detect leakage in risky areas is depicted in their suggested prototype. This system can instantly read and transfers the data through wireless communication like Bluetooth whenever leakage happens in a specific location. In(10; 11), the authors provided a survey of the numerous regarding leakage localization and detection. According to the results of their survey, multiple ways can be used for detecting gas pipeline leakage. Since their original recommendation, various solutions have been improved because to advancements in sensor manufacture and processing power. The majority of detection techniques, they added, are based on the measurement of a particular physical property or the presence of a certain physical phenomenon. In (12), An IoT-based smart gas monitoring system is discussed by the authors. They developed a system using an Arduino Uno controller. The main modules, besides the Arduino UNO, are the MQ2 sensor, the Wi-Fi module, and the load cell. An internet feature has been added to this project. The load cell is a component of the internet. LPG cylinder weight is measured via a load cell. The output from the load cell is then sent into the Arduino UNO. The Wi-Fi facilitates communication among the other modules. LPG level of the cylinder is highlighted on the LCD. In order to complete the automatic booking process of a cylinder, this technology notifies the gas agency when the gas level falls below the threshold. In(13), a Model-based LPG leakage detection and isolation system is proposed to detect gas leakage. They used the gas detection sensor to find any gas leaks. The remaining gas amount is measured using the weight sensor. If there is a gas leak, the exhaust fan is turned on. The Max232 helps to connect GSM to a microcontroller, and a buzzer signals a gas leak. In(14), the authors suggested an autonomous LPG leak detection trolley system with safety considerations and cylinder booking system by using PIC 16F877a.v When a gas leakage is detected, this system receives an alert via message, and the cylinder is automatically booked to the agency using a GSM SIM 800/300/900 module when the gas level reaches the minimum. In this system, the gas distribution companies require user registration and a database system for each gas cylinder with a corresponding phone number to process the booking request. In(15), the authors suggested a system with leakage detection and level monitoring function. It also has the facility of auto-renewal. This system detects gas leaks and continuously monitors the initial LPG level and throughout use. When the solid-state gas sensor MQ-5 detects a gas leak, the GSM/GPRS wireless modem sends an SMS alert using the ARM7 microcontroller. In(15), the authors suggested an Arduino-based LPG monitoring and automatic cylinder booking system with an alarm system. This system alerts the homeowners by activating the buzzer and sending an SMS. Autorenewal of the cylinder is also available in this system. To prevent major accidents, an Arduino Mega2560 microcontroller is combined with an MQ-4 sensor and an LM35 temperature sensor. The cylinder's weight is continually monitored by weight sensor. In(16), The authors recommended using an integrated circuit and MQ-9 for dangerous gas detection. They mostly employed an embedded design, which comprises standard input and output devices such as switches, relays, solenoids, LEDs,

radio frequency devices, and sensors for data such as temperature, humidity, light, and so on. In(9) the authors unveil an android-based robot that automatically detects and indicates the presence of gas. A little mobile robot that can find gas leaks in dangerous areas is depicted in their suggested prototype. If there is a gas leak in a specified place, the gadget instantaneously scans and communicates the data to an Android smartphone over a wireless connection such as Bluetooth. They present some new or ancient gas detection methods. The approaches that are suggested in this study are non-technical and hardware-based, and they comprise active, optical, and auditory procedures. The majority of detection procedures in their field are based on the measurement of a certain physical characteristic or the appearance of a specific physical phenomenon.

In(23) the authors provided a variety of SCADA I/F-based models for identifying gas leaks. The SCADA system is in charge of transmitting pipeline system data to transient simulation. Every 30 seconds, dynamic metrics including pressure, flow, and temperature are gathered. On the basis of real data, precise numerical methods are used to model transient flow. In(24) the authors described the process used to create their project, an ARM7-based high-performance automated system for LPG refill booking and leak detection. The paper is structured in a basic manner, such as the LPG cylinder booking unit, the gas leakage monitoring unit at the client end, and the server system unit at the distributor end. In(25) using autonomous gas detection and indication golem, the author introduced a new golem. A little mobile golem that can detect gas leaks in dangerous areas is seen in their projected design. The golem immediately scans any instances of gas leaks in a given area and communicates the information to the golem mobile using Bluetooth or other wireless technology. A GSM module is used by the microcontroller to deliver the "EMERGENCY ALERT" message to the relevant cell phone numbers, which is subsequently displayed on a digital display. In(10) an embedded system-related MQ-9 computer circuit is described. The MQ-9 sensor alerts the semiconductor diode and activates a buzzer if any leakage happens.

2 Hardware Requirements

In order to develop an efficient and portable system for usage several hardware elements are normally used. In this section we are going to discuss the common hardware's thar are normally being used to design an efficient LPG monitoring system. These basic hardware components include the Arduino Uno, Gas Sensor, Weight Sensor, Microcontroller, Buzzer, Liquid Crystal Display (LCD), GSM Modem, Breadboard, Jumper wires etc.(6; 26; 27; 28; 29; 30; 31),Figure 1 to 10 highlights the different hardware used in this type of system.

a). **Arduino Uno**: The Arduino UNO is a microcontroller board with an ATmega328P processor. It has 6 analogue inputs, a 16 MHz ceramic resonator, a USB port, a power connector, an ICSP header, and a reset button.

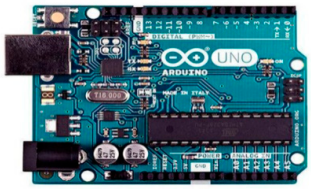

Figure 1: Arduino Uno

It also has 14 digital I/O pins, six of which are PWM outputs. Fig 1 highlights the hardware.

b). **Gas Sensor**: MQ-6 is a semiconductor-type gas detecting sensor made of tin dioxide.

Figure 2: MQ-6 Gas Sensor

It has limited sensitivity to alcohol, cigarette, and cooking odors, but it can detect butane and propane. SnO_2 is the main component of this sensor. Fig2 highlights the gas sensor.

c). **Weight Sensor**: The load cell module is the weight sensor in this case.

Figure 3: Weight Sensor

For electronic scales to display weights in digits, a load cell, a weight measurement device, is necessary. However, load cells are not limited to weight calculation on electronic scales. The sensor or passive transducer converts applied force into electrical impulses. Fig 3 highlights the weight sensor.

d). **Microcontroller**: An 8-bit CMOS microprocessor called the ATMEGA16 has 16 Kbytes of flash memory that can be programmed and erased for read-only use (EPROM).

Figure 4: ATMEGA16 Microcontroller

It delivers great performance while consuming less electricity. The ATMEGA16 integrates a flexible 8-bit CPU and Flash on a monolithic chip to provide a highly adjustable and affordable solution to many embedded control applications. Fig 4 highlights the microcontroller.

e). **Buzzer**: An instrument that offers an audible alarm regarding the leak is a buzzer.

Figure 5: Buzzer

It also rings to notify you to refill the cylinder when the gas level drops below the threshold level. Fig 5 highlights the buzzer.

f). **Liquid Crystal Display (LCD)**: A 16X2 LCD is used as the visual display. This LCD was chosen because of its inexpensive cost and simple programming.

Figure 6: LCD Display

It displays several warnings, including alert messages for cylinder bookings and gas leaks, among others. Fig 6 highlights the LCD.

g). **GSM Modem**: The operation and support system (OSS), switching system (SS), and base station system are the three components that make up the GSM network (BSS).

Figure 7: GSM Module

When a leak occurs, the microcontroller signals the GSM module, which then delivers the message to the relevant mobile phone. It has one SIM card and a unique identifying number. Fig 7 highlights the GSM modems.

h). **Jumper Wires**: Jumper wires are commonly available in three configurations: male-to-male, male-to-female, and female-to-female.

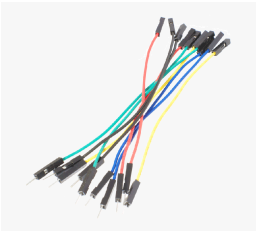

Figure 8: Jumper Wires

The difference is in the wire's termination point. Male ends feature a protruding pin and can plug into items, whereas female ends do not and are used to plug things onto. Fig 8 highlights the jumper wires.

i). **Relay**: Relays are switches that run on electricity. A magnetic field produced by current passing through the relay's coil pulls a lever and modifies the switch contacts.

Figure 9: Relay

Relays are double throw (change over) switches with two switch positions since the coil current can be on or off. Relays enable a single circuit to switch a second circuit that may be entirely independent of the first. For instance, a relay can be used in a low voltage battery circuit to switch a 230V AC mains circuit. Fig 9 highlights the relay.

j). **Breadboard**: A breadboard is a solderless device used for prototyping electronics and testing circuit

designs. Most electrical components in electronic circuits can be coupled by placing their leads or terminals into the holes and then connecting them with wires where necessary.

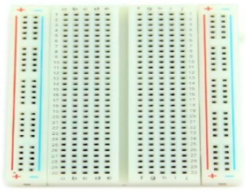

Figure 10: Breadboard

The breadboard contains metal strips below it that link the holes on top of the board. Fig 10 highlights the Breadboard.

3 Conclusion

This paper focuses on the investigation of various gas leakage detection systems for home safety and LPG-level monitoring devices that regularly notify users on how much LPG is utilized each day. Considering the papers discussed above, it can be summarized that the reviewed systems are capable of detecting gas leakage within a specific area. Furthermore, some systems can monitor the gas level of the cylinder to book a cylinder as needed. Apart from the aforementioned features, it was observed that different alert mechanisms, such as an LCD, a buzzer, and an SMS notification system, were available in some systems. A variety of leakage monitoring systems are available on the market. As a consequence of advancements in sensor production and processing power, certain strategies have been upgraded since they were first proposed. However, a leak detection system that can immediately shut off the gas supply if a leak is discovered will be more efficient.

Conflict of Interest

The authors declare no conflict of interest in this reported communication.

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