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Efficacious L.P.G. Leakage Detector and Auto Shut-Off System Using Arduino Uno AT mega328

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ABSTRACT: LPG is a valuable and efficient fuel, mostly used in residential and commercial places for cooking. It is imperative if proper care is taken while using it safely. LPG mostly filled in cylinders which are strong and can't be damaged easily. However, leaks can occur from gas cylinder, regulator and gas pipe tube connection when these are not in a good condition and may cause an accident. Accident may lead to health issues like suffocation and possibly cause a blast on the ignition of any flame or electric supply. The objective of this paper is to develop a system that can detect the leakage of Liquefied Petroleum Gas in the vicinity where it is put into service and takes necessary action to avoid calamities. The proposed system is designed and implemented to meet the health and safety standards for the Cookery and Bakery lab. of Hotel Management Department of Dr.B.R.Ambedkar Institute of Technology, Port Blair, Andaman & Nicobar Islands. The proposed system is tested and the results are verified by producing an early warning signal under the less severe condition and activate a high pitched alarm during the leakage of LPG and automatically shut down the gas pipeline during the leakage of gas to provide a safeguard to the users.

KEYWORDS: MQ-6 Gas Sensor, Arduino Uno, Proteus Software, Solenoid Gas Valve, Audible Alarm

I. INTRODUCTION

LPG is a smokeless fuel commonly used for cooking, water heating systems and other heating purposes in domestic, commercial and agronomic applications. LPG stands for Liquefied petroleum gas consist of propane (C_3H_8) or butane (C_4H_{10}) or mixes including both propane and butane. A study has shown that cooking in traditional way, using firewood or cow dung, is equivalent to smoking 400 cigarettes a day. Mostly users of firewood and cow-dung has to make a lots of effort and patience to cook the meal including blowing air in the firewood chulah and breathing the smoke may cause ill effect to their health. This traditional cooking method has been overcome with the use of LPG cooking as a fuel though reduces the harmful effect of using firewood and cow-dung and also "LPG prevents in-house pollution". On 1 May, 2016, Government of India launches a scheme to provide free connection to BPL families of rural and urban areas. As per scroll report, data shows that year-on-year increase in the consumption of LPG rose from 9% to 9.8% from 2015-16 to 2016-17, while the increase in LPG customers in the same time period rose from 10.2% to 16.2% [1].

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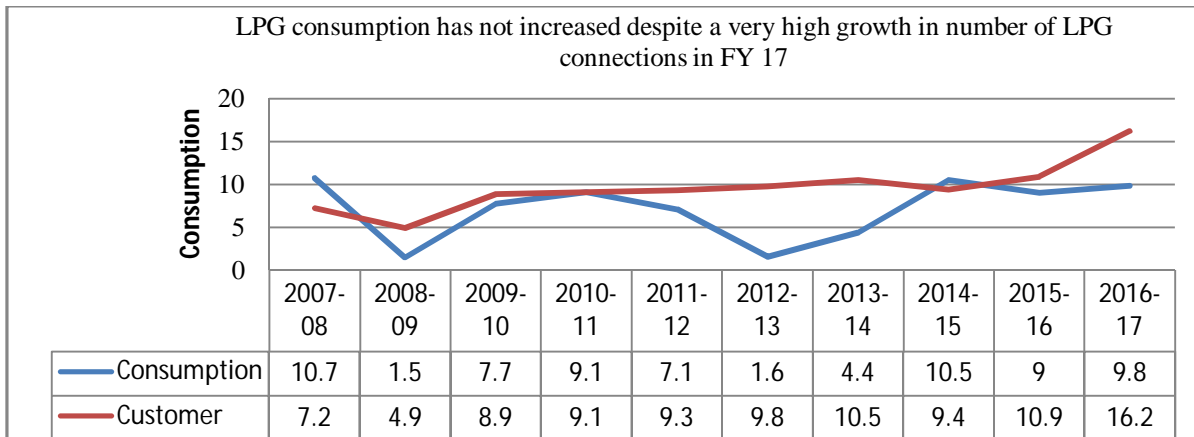


Fig.1: Graph between LPG consumption v/s LPG connection in financial year-2017

With the increase of LPG connection and consumption, it is important to educate the users with the safety measure to avoid any accident due to LPG as it is highly flammable, toxic and has a risk of fire or explosion. In addition to this, it is a need for a system which can detect and also prevent from leakage of LPG.

From a survey during the period from "2010" to "2106" it can be found that 17% of fire accidents are due to LPG leakage. There is a necessity of safety systems that provides safety assurance and takes safety measures in the absence of users. Commonly it is ignored as an absolute need for safety but since there are risks from these, there should be a safety system installed for worst case scenarios.

The main aim of this work is to detect LPG during leakage and takes safety measures in the absence of the users. The objective of this work can be divided into two, first is to indicate the presence of LPG in the atmosphere which is of dangerous level and to notify the personnel of gas leakage by a alarm and LED indication. Second is to take necessary precaution by auto shut off the passage of gas through gas pipe line/ cylinder using solenoid gas valve to prevent any accidents like suffocation or blasting of LPG cylinder from ignition.

In this work, an attempt has made to design and fabricate a safety device for detecting LPG and natural gas that avoid any accident from the leakage. The proposed device examines the level of LPG and Natural gas as well as the other gases which are composed of propane and butane concentrations in the air and activates the audible alarm and also auto shut off the passage of LPG, when it exceeds the threshold value of 200ppm.

II. LITERATURE SURVEY

Oyedeko K.F.K. et.al. [2], proposed a model using MATLAB software programming to study the transient flow analysis within the various pipeline. The mathematical equations are used for the measurement of pressure, flow and temperature for both upstream and downstream ends in the system to detect the leakage. The simulation and testing of a proposed model provides satisfactory results by blowing an alarm system with the SCADA network for online monitoring of the pipeline. The efficiency of the model is greatly affected by the performance of the observer, provision.

Zhao Yang et.al. [3], has developed a leakage detection model using three conservation law in hydromechanics and the state equation for the study of transient simulation model and volume based model. Parameters such as pressure, flow and temperature are used in the model for observation and are acquired through SCADA (Supervisory Control and Data Acquisition) system. Experiment were carried using the various factors which influencing the leakage position.

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Vol. 6, Issue 10, October 2017

The test result from the experiment concludes that the leakage and outlet presence are more important parameters compared to the coefficient of frictional resistance and pipeline diameter. The more leakage increases, the closer leakage point approaches pipeline outlet. Leakage location is closer to outlet when pipe-line outlet pressure becomes bigger.

Eungyeong Kim et.al. [4], developed a new neural genetic classification algorithm (NGCA) performs better than the genetic algorithm (GA) and artificial neural network (ANN) and implemented experimentally to for accurately recognizing the odor using pattern recognition in order to enhance the selectivity of gas sensor arrays. The proposed system can enhance the reproducibility, reliability, and selectivity of odour sensor output, so it is expected to be applicable to diverse environmental problems including air pollution, and monitor the air quality of clean-air required buildings such as a kindergartens and hospitals.

V. Abishek et.al. [5], has developed a system for detection of gas leakage incorporated with the tripping mechanism of main power supply to avoid any explosion due to it. The developed system used transmitter and receiver module interfaced with the microcontroller programming. The developed system has implemented and tested to conclude that the working of the system depends upon the concentration of gas present in the system. As the concentration level of the gas reaches to the threshold, the main power line gets shut-off and the alarm sounds loudly.

Selvapriya C. et.al. [6], has developed a microcontroller based model for leakage of gas in a closed environment using sensors. The developed hardware was interfaced with the microcontroller programming and tested. The test result produces the audio and visual alarm to alert the human and also sends a short message service (SMS) to the user. The sensor has excellent sensitivity combined with a quick requital time. The sensor has also sense Iso-butane, propane and cigarette smoke.

Ashish Shrivastava et.al. [7], has designed and developed a system that can detect the gas leakage and stop it automaticall in vulnerable premises. The system used a high sensitive sensor to sense the concentration of gas such propane (C_3H_8) and Butane (C_4H_{10}). GSM (Global System for Mobile Communication) module is incorporated, which send a warning SMS to the user. The developed system was tested and worked satisfactorily by taking a small amount of LPG gas near to the sensor and observe that abuzzer sounds loudly and the message was displayed on the LCD screen.

S.Sivajothi Kavitha et.al. [8], the proposed wireless home gas leakage system consists of three major modules: the gas leakage and level detection and transmission module (GSM/GPRS MODEM), and the receiver module (GSM mobile). The gas leakage detection and transmission module detects the change in concentration of LPG and natural gas and activates an audio-visual alarm when it exceeds a certain threshold. Furthermore, it sends another alarm message to the mobile. Continuous monitoring of the level of the LPG is done to detect the weight of the cylinder at the time of dispatch and throughout the usage. Auto renewal system is alerted when the cylinder is going to be emptied and auto booking is done with the gas station also giving the information to the consumer.

R. Naresh Naik et.al. [9], proposed a system that makes entire LPG cylinder booking procedure automated without human intervention. Proposed system continuously measures the weight of the cylinder and once it reaches the threshold value it will automatically sends message to the authorised LPG agent so that they can deliver the LPG cylinder in time. Along with the automated cylinder booking it was designed for the safety of user in which the control system monitors the leakage of LPG gas and alerts the user to avoid accidents by using ARDUINO Mega.

Jitendra Sharma et.al. [10], proposed a system that senses the gas leakage through gas sensor and sends the signal through microprocessor to the relay. After the gas leakage has exceeded the threshold value, the relay sends a signal to trip the power to prevent accident.

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VasudevYadav et.al.[11],proposed the use of LPG gas leakage detector which help in turning off the switch when there will be an emergency in the users absence by using 8051 Microcontroller. GSM modules were used to send a SMS to the emergency number provided to it to alert the user via audio and visual indications.

III. PROPOSED METHODOLOGY AND DISCUSSION

The proposed system comprises of LPG gas sensor, Arduino UNO, LCD display, Auto On-Off system and alarm circuit.

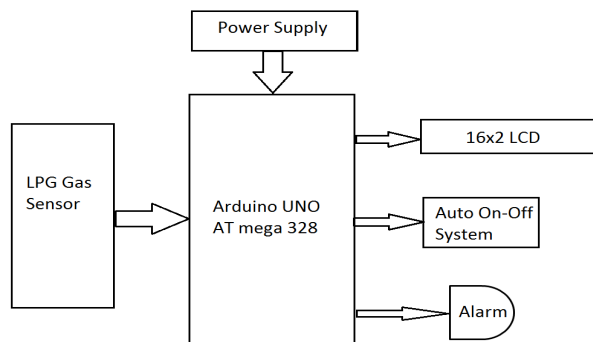


Fig.2: Block diagram of a proposed system

Block diagram description:

Arduino UNO: The Arduino UNO is a microcontroller board based on the AT mega328 operates on external power supply or via USB connection. The external power can be provided through an AC-DC adapter or through a battery. The board can operate on an external supply of 6-20 Volts. If the supply is less than 5Volts, the board may be unstable. If using more than 12Volts the voltage regulator may over heat and damage the board. Therefore, the recommended range is 7-12 volts. It has 14 input/ output digital pins, out of which 6 provide PWM output. It also comprises of 6 analog pins (i.e. from A0-A5), 6 power pins, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP (In-Circuit Serial Programming), TX/RX LEDs, “TEST” LED 13 and reset button.

MQ-6 Gas Sensor: In this work, MQ-6 gas sensor is used which is a highly sensitive to LPG, iso-butane, LNG& propane and low sensitive to alcohol and smoke. As the concentration of leaked gas increases, the conductivity of gas sensor increasesand converts the one form of signal into another form of signal. MQ-6 sensor comprises of a heater that needs a supply heat up and takes minimum time to detect the LPG. It has fast response, stable and long life and is simple in operation.



Fig.3: Pictorial view of MQ-6 gas sensor

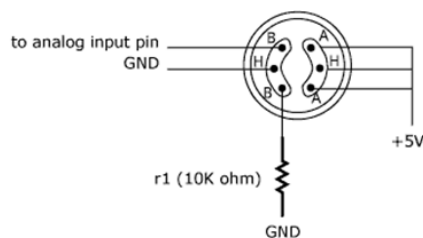


Fig.4: MQ-6 gas sensor circuit connection

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Vol. 6, Issue 10, October 2017

MQ-6 Sensor Module: Sensor Module is designed to detect the presence of a dangerous LPG leak in your home, car or in a service station, storage tank environment by interfacing with Microcontroller without ADC Channels and programming. In this LPG Gas sensor module two pots are included, one for trigger level setting and the other for setting sensitivity of the sensor. It allows determining when a pre-set LPG gas level has been reached or exceeded. The module uses MQ-6 sensor to sense LPG leak. The MQ-6 can detect gas concentrations anywhere from 200 to 10000 ppm.



Fig.5:MQ-6 gas sensor module

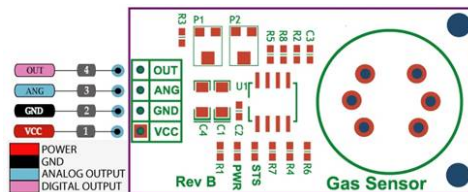


Fig.6: LPG gas sensor pinout diagram

Gas Safety Shut Off Valve: Solenoid valve is an emergency shut off valve, which cuts off supply of gas, in case of any major hazard caused in Domestic system due to either leakage of supply line from Cylinder to Gas Stove or failure of equipment such as low pressure regulator, Gas stove etc. thus avoiding any potential gruesome accident. The signal to operate the valve is given by sensor or a manual switch.

Solenoid valve operation under normal condition

- 1) The valve can be operated by a manual switch to turn ON and OFF the valve.
- 2) The valve will remain without changing its state till there is a leakage.

Solenoid valve operation under leakage condition

Gas Safe will automatically shut-off the gas supply from the cylinder due to major leakages of gas caused due to:

- 1) The rupturing of a tube or pulling off the stove or regulator.
- 2) The regulator failed to function properly.
- 3) The tube catching fire.

Audio Indicator: Depending upon the application, the audio indicator output may be local, remote or a combination. In this work, solenoid based siren alarm, which is a local alarm which do not include monitoring is used, though may produce sound which may be useful for the people to evacuate during any hazardous condition.

LCD Display: In this work, LCD display is used to display the TRIP condition and the percentage value of gas concentration. Here the trip threshold value is set at 30% when the concentration level of gas exceeds the threshold value, the percentage value of a gas concentration display on the LCD display. Liquid crystal display (LCD) has material which combines the properties of both liquid and crystals. They have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an order form similar to a crystal.

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Proposed System Operation:

a) **Software Implementation:** The proposed system is designed and simulated on Proteus software.

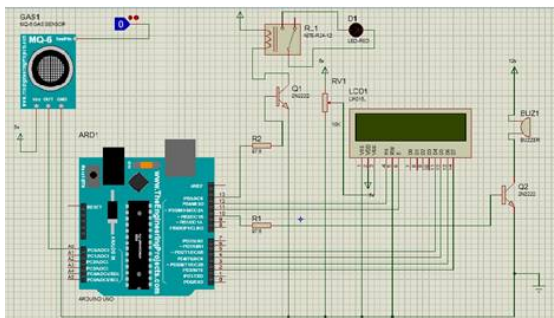


Fig.8: Simulation for initial condition (without leakage of gas)

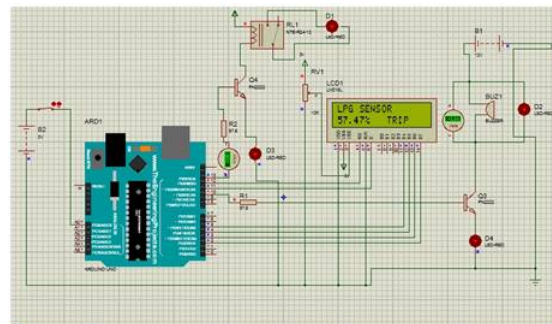


Fig.9: Simulation showing trip condition (with leakage of gas)

In fig.8, the OUT and GND pin of MQ-6 gas sensor is connected to pin A0 and GND of Arduino Uno, which is zero means the sensor is not actuated (i.e. 0 for OFF state and 1 for ON state). As the zero signal is received to Arduino Uno from gas sensor, both the speaker and gas value relay remain in non-operating condition. No LED will glow.

In fig.9, a 3V battery replica of a MQ-6 gas sensor is connected at pin A0 and GND of Arduino Uno, which means that the high signal is fed to Arduino Uno, both the speaker and gas valve relay switches to operating condition. LCD displays the message as “LPG SENSOR 57.47% TRIP” and LED glows.

b) **Hardware Implementation:**

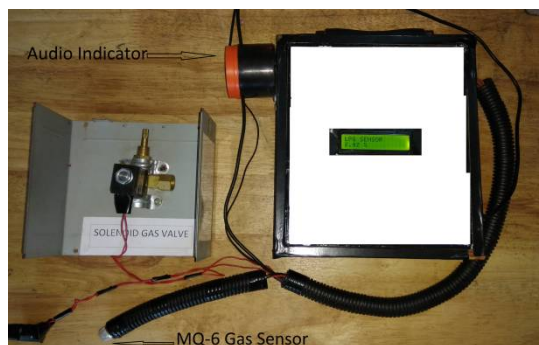


Fig.10: Prototype of proposed system during initial condition (without leakage of gas)

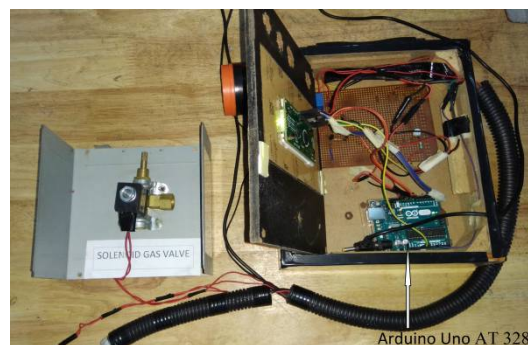


Fig.11: Implementation of components for proposed system

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 6, Issue 10, October 2017

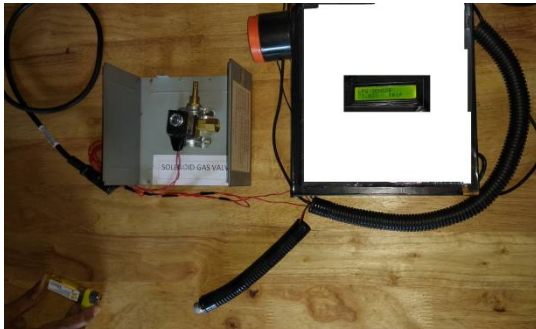


Fig.12: Gas lighter is far from the MQ-6 gas sensor (for low level concentration of leaked gas)

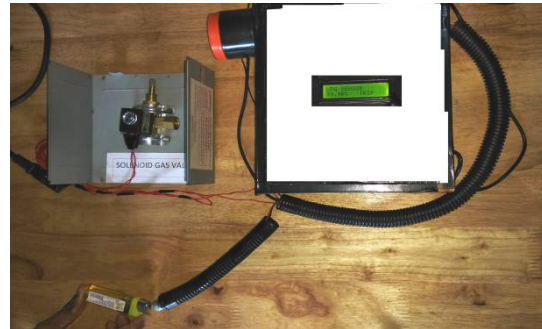


Fig.12: Gas lighter is near to the MQ-6 gas sensor (for high level concentration of leaked gas)

Circuit Operation:

Output of the MQ-6 gas sensor is connected to the analog input pin A0 of the Arduino Uno. Digital pin 10 of the Arduino is used for controlling the audio indicator and digital pin 13 used for controlling the solenoid gas valve relay. Here the TRIP threshold is set to be 30%. User can set the threshold point in the Arduino programming. When the threshold value is exceeded the Arduino will set digital outputs HIGH and LOW according to the program.

When the concentration level of leaked gas in the air is below the threshold value, the output 13 and output 10 will be low. The transistor Q1 and Q2 remain in cut-off condition. Therefore, the proposed system does not actuate and the display will indicate the low level concentration of leaked gas present in atmosphere.

When the concentration level of leaked gas in the air is above the threshold value, the output 13 and output 10 will become high. The transistor Q1 and Q2 operates in saturation region and therefore the solenoid gas valve relay actuates and discontinues the passage of gas from cylinder or pipeline and audio indicator sounds loudly. The display will indicate the concentration level of leaked gas present in atmosphere.

IV. EXPERIMENTAL RESULTS

The testing of the proposed system was carried out using a lighter as a replicate of a LPG gas source. The lighter was held at a long distance to imitate low level concentration and was gradually brought closer to the gas sensor to imitate high level gas concentration. The proposed gas leakage detector showed an excellent performance and provides satisfactory results regarding the gas leakage for the period of testing. The test was carried out several times and the result was the same in almost all of the cases. The sensor takes some time around 1.5 to 2 minutes to get heated and ready to sense the gases. The sensing time is almost immediate once the sensor is ready to sense. Once the concentration of gas reduces below 30% of the threshold value then the solenoid gas valve gets deactivated and audio alarm indicator goes off automatically.

The results are summarized below as follows:

S.No.	Test Condition	LED	Buzzer	Solenoid Gas Valve
1	No gas leakage	Off	Off	Off
2	Low Level gas leakage	Glow	Sound	Activates
3	High Level gas leakage	Glow	Sound	Activates

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Vol. 6, Issue 10, October 2017

V. CONCLUSIONS

An Arduino Based Gas leakage detector system meets the safety requirements, which are presented in the paper. The proposed system is designed, fabricated and installed at the Cookery and Bakery Lab. of Hotel Management Department of Dr.B.R.Ambedkar Institute of Technology, Port Blair The test results are obtained using butane based lighter as a replicate of a LPG gas source. The test result verify the effective and efficient operation of the prototype by detecting low and high gas leakage levels and auto shut-off the gas supply and alert the user by providing an audible alarm warning signal. The proposed Arduino based gas leakage detector provides high and fast response than the manual operation during the critical situations. The system can be installed for detecting the various leakage gases at residential, hotel restaurants, other commercial commodities and industrial area to avoid imperiling of human lives.

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