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LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System

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Abstract. A crucial requirement used in everyday human life is the use of liquefied petroleum gas (LPG) or, more generally, cooking gas. However, problems arise for LPG users when the cooking process is disrupted due to running out of cooking gas without them realized that the volume of gas has reached a critical level. In addition, gas leaks may also occur which can cause the house fire. Therefore, this study aims to develop a product that can monitor the remaining volume of cooking gas content in a gas cylinder using a load sensor. The LPG weight value is through LCD display and LED from three different levels, which is green (full), yellow (medium), and red (critical) where it receives programming instructions from Arduino Uno. The product also performs a function of gas leak detector by using the MQ-2 gas sensor and the user will receive a notification warning about the gas leak via buzzer and SMS sent by ESP32. The development process for monitoring scale and gas leakage detector for liquid petroleum gas (LPG) is based on the adapted from the Engineering Design Process Model (EDP), which consists of five phases, namely identify the problem, gather information, select the best solution, develop model, testing and evaluation. The results show that the developed product able to functioning well. However, in terms of product design there is still room for improvement especially for the size of the product and the gas sensor position to make it more user friendly.

1. Introduction

Malaysia is common in using Liquefied Petroleum Gas (LPG) for cooking. It is widely utilised in household, industrial, and commercial settings. LPG is utilised not just for cooking, but also for heating and drying. In Malaysia, many volumes of LPG cooking gas are available; however, the most usually utilised size is 14 kilogramme. One problem that often occurs to LPG users is to detect the mass of LPG gas that can interfere with the cooking process when the gas runs out while the cooking activity is in progress. According to Akif (2018), the cooking process is disrupted when the stove fire is extinguished suddenly which indicates that the cooking gas has run out. This result in the quality of food is also affected. The problem is exacerbated when the home gas delivery service does not answer the user's call at that critical moment. Meanwhile, Effi Saharuddin (2015) stated the biggest issue for cooking gas users is that it is difficult to predict the remaining volume of gas, and issues develop when there is an occurrence of running out of LPG during cooking late at night and all stores are closed.



In addition, gas leaking is a problem that LPG cooking gas users face as well. Gas leaks are one of the leading causes of house fires, which can result in both property and life loss (Sitan & Ab Ghafar, 2018). This is because consumers cannot identify the existence of gas leaks that occur around the LPG gas tank since they cannot be seen with the naked eye and frequently go unnoticed. In the absence of these gas leak detectors, the risk of fire caused by LPG cooking gas increases. According to Malaysian fire incident statistics for year 2018, there were 398 total fires caused by gas or oil stoves (Fire and Rescue Department, 2018). As a result, a system to monitor the mass of the amount of LPG gas should be developed to help customers monitor the remaining volume of cooking gas utilised by them. The system must be capable of detecting gas leaks and alerting customers, ensuring the safety of cooking gas users while also reducing the danger of home fires caused by LPG gas explosions.

According to the findings of market survey on e-commerce platform online, there are various devices on the market that may assist solve difficulties linked to cooking gas, but they work independently. There is a Gas Scale product selling in the market that able to measure mass and LPG leak detector; however, it is still in the prototype stage and is not available in Malaysia. Furthermore, smart scales used as a location to store portable LPG cooking gas canisters are available on the market, although they lack leak detectors. However, there are several leak detection devices available on the market that merely perform the leak detection function. There are various types of products that are nearly identical to the products developed, but they are manufactured elsewhere, thus the cost of shipping to Malaysia is extremely high.

Therefore, in accordance with current technology breakthroughs, the creation of novel solutions that assist LPG cooking gas customers in resolving the challenges involved is being aggressively pursued. To assist customers in identifying the real gas content scale before running out, a system capable of detecting the measurement scale and identifying LPG cooking gas leaks, ensuring safety and lowering customer load is being developed. It is intended that the product developed may be purchased by customers of various levels of living standards of cooking gas 14 kg at an appropriate and accessible price, in addition to the range of functions offered on this product.

2. System Design and Development

The old way of determining the depletion of LPG used by users is just looking at the colour of the flame. Traditional techniques are time consuming and incorrect, potentially interfering with the cooking process and resulting in food waste if there is no new gas storage in the house owing to needing to wait for the gas to be replaced. Not only that, but fires caused by cooking gas leaks are common among LPG users at home, and it may even happen when the users are outside the region, resulting in a fire. With this dilemma, there is an idea to design and develop a system that able to minimise the burden on customers while maintaining consumer safety to avoid household fires.

This system is capable of detecting the amount of cooking gas remaining in the gas cylinder by showing the scale status on Liquid-Crystal Display (LCD) and Light Emitting Diode (LED). The LCD will shows in three levels, namely full level, medium level, and critical level. The system will also using ESP32 microcontroller to send a notification message through the web server in the case of a leak even if the user is not at home. In summary, the scope of this LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System are:

- i. This system is suitable for users of 14 kg LPG cooking gas cylinders, because all brands of LPG cooking gas dealer are the same.
- ii. The system is designed in a small scale and is user -friendly and can be easily moved.
- iii. This system focuses on home and domestic consumers.
- iv. The load detector detects the weight of a gas cylinder and sends a signal to the LCD, and LED lights will turn on, which serve as a tangible representation of the three degrees of residual gas content, namely green (full), yellow (medium), and red (critical).
- v. The gas detector detects gas leaks and delivers a signal to the alarm the consumers by using ESP32.

The engineering design process model (EDP) suggested by Haik & Shahin (2011) was employed as the product development methodology. EDP is a method that describes the product development process in detail that includes the development, testing and evaluation phases, and even contains the phase of improvement or change to improve product quality. However, for the development of this LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System, the researcher only adapted the EDP model by involving only five phases, starting with the problem identification step until the evaluation and testing step. Figure 1 illustrates the steps of the design and development process of the LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System.

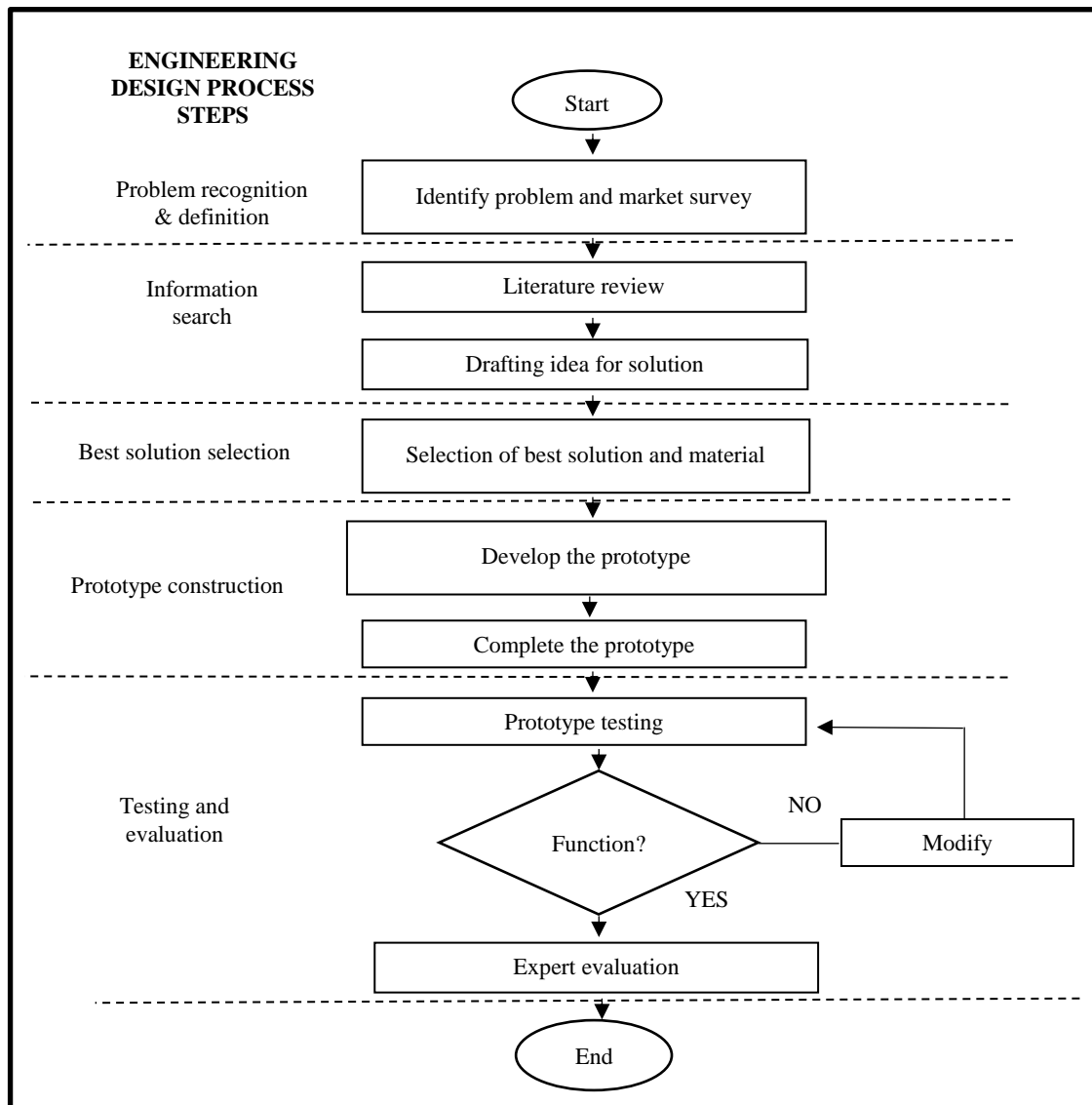


Figure 1. LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System Development Flowchart.

Figure 2 (a) shows the illustration of a gas cylinder putting on the LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System. Meanwhile Figure 2 (b) shows the specification of the system that with length x width x height = 43.5cm x 43.5cm x 15cm. On the other hand, Figure 3 shows the

pictorial diagram of the circuit for LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System. The circuit was developed from load sensor, gas detection sensor, buzzer, LEDs, Arduino Uno, ESP32, LCD screen and modul HX711. Figure 4 is showing how the system operating to monitor the mass of gas and sending SMS to the user when there is any gas leaking being detected.

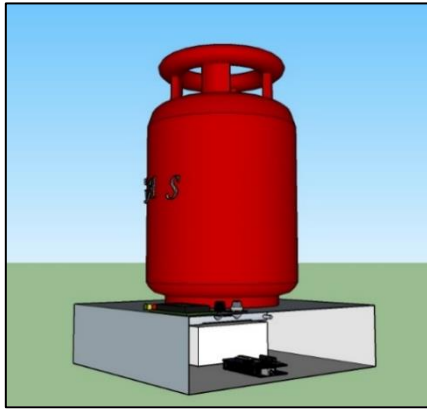


Figure 2(a). Illustration of the gas cylinder putting on the system

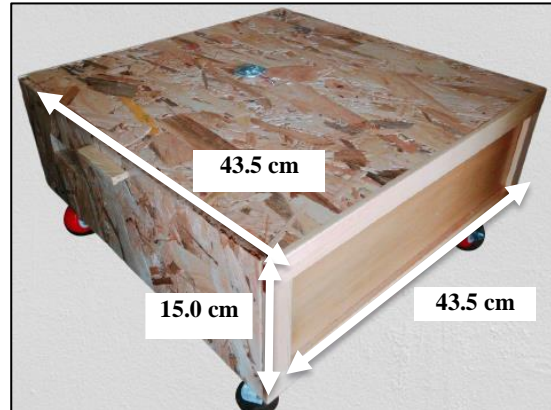


Figure 2(b). The specification of the system

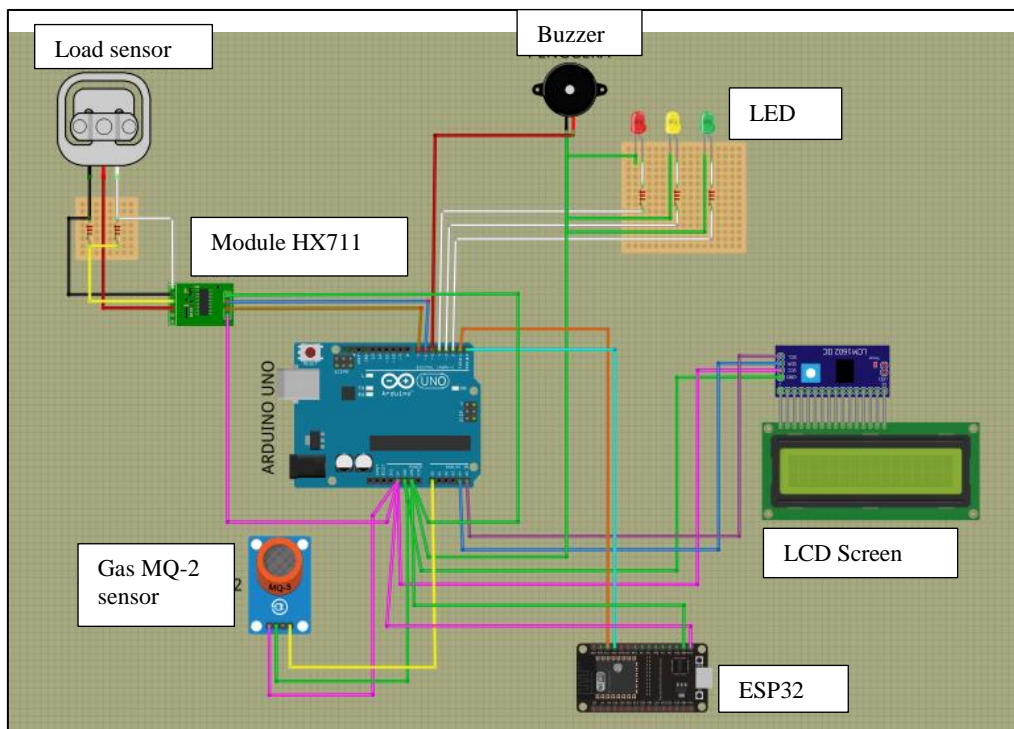


Figure 3. Pictorial diagram of the circuit for LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System

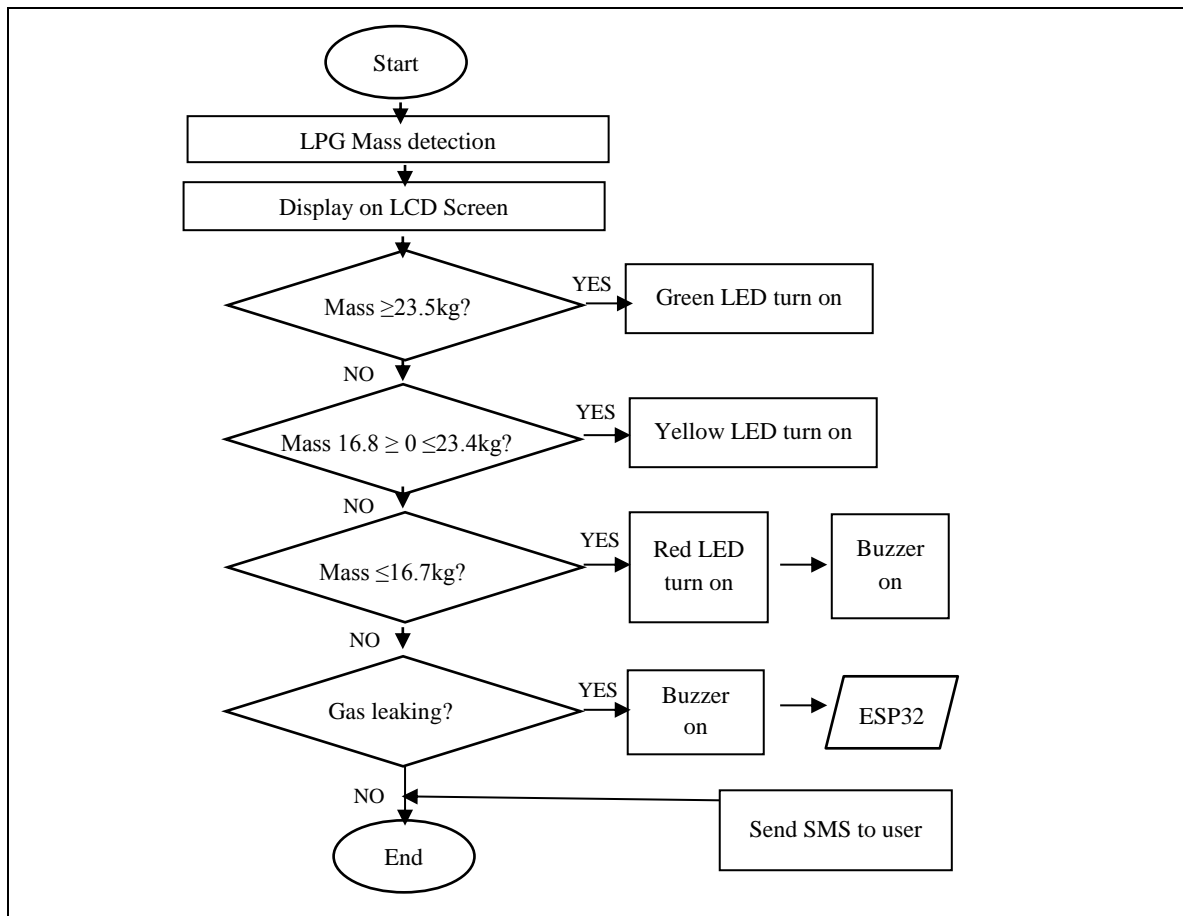


Figure 4. Operating flowchart of LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System

3. Results And Discussion

The aims of this system design and development are to benefit:

- a. Home LPG users who can make preliminary arrangements to replace old cooking gas before it runs out and disrupts the cooking process. Even these users can avoid fires caused by cooking gas leaks.
- b. With the support of ESP32, LPG consumers are alerted in the case of a gas leak at home.
- c. Restaurant owners can also preserve food quality if they can identify the remaining amount of LPG gas early and convert it before it interferes with the cooking process.
- d. Customers at the restaurant do not have to wait long for meals to be ordered as a result of the restaurant running out of gas.
- f. LPG gas dealers can alleviate the strain put on them by LPG clients who need quick gas supply.

Therefore, several testing on the functionality of this system were conducted: (i). Microcontrollers functionality testing; (ii). SMS functionality testing; (iii). Load detector functionality testing; (iv). Gas detectors functionality testing; (v). LCD display functionality testing; (vi). LED lighting functionality testing; (vii). Alarm functionality testing. System functionality testing was conducted to ensure that the LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System able to operate as designed. The Arduino is the main microcontroller to give instructions to each component in the system. The LCD screen and three LEDs with green, yellow and red colour play a role as physical displays of the cooking gas volume level. When the gas level has reached a critical level, buzzer will turn on and buzzing to warn the user that the cooking gas is about to run out and at the same time the LCD display will display the gas status "Critical" and a red LED will turn on. Table 1 is the testing results this function of LPG Mass Monitoring Scale with Automatic Gas Leakage Detector System.

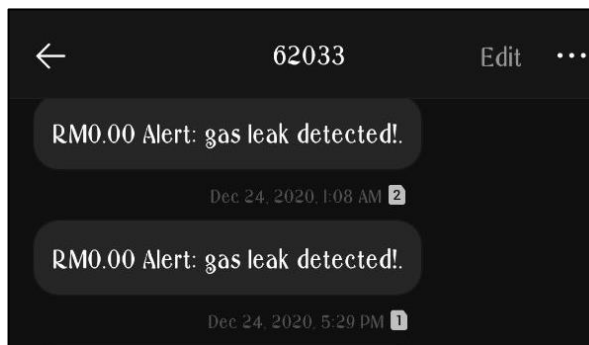
TABLE 1. Load Detector and Gas Leaking Detector Functionality Testing.

Mass (kg)	LPG	Status LPG	LED			Buzzer
			Green	Yellow	Red	
25.58		OK	ON	OFF	OFF	Not buzzing
24.10		OK	ON	OFF	OFF	Not buzzing
20.13		OK	OFF	ON	OFF	Not buzzing
16.73		CRITICAL	OFF	OFF	ON	Buzzing
16.62		CRITICAL	OFF	OFF	ON	Buzzing

In addition, this system is able to detect gas leaks that may occur of the LPG cooking gas cylinder. The MQ-2 gas detector will operate when gases volume in the range of concentration between 200ppm-5000ppm (Hasibuan & Idris, 2019). When the MQ-2 detect the gas concentration volume reaches 250 and above, data is sent to the ESP32 to process the instruction. ESP32 will request authentication to the web server to communicate with the SMS gateway before the gas leak information is sent to the user. Users will receive a warning notification via SMS on the number that has been registered and at the same time the buzzer will also buzzing and the LCD display displays the status "Leaking Gas" (refer Figure 5). Table 2 shows is the results of LPG gas leakage output testing.

TABLE 2. LPG gas leakage output testing.

Gas concentration (ppm)	LCD Screen Status	Buzzer	SMS notification
58	-	Not buzzing	Not received
117	-	Not buzzing	Not received
256	"GAS BOCOR"	Buzzing	Received
291	"GAS BOCOR"	Buzzing	Received
243	-	Not buzzing	Not received

**Figure 5(a).** SMS notifications received by user**Figure 5(b).** : LCD screen displays the LPG mass and gas leakage status

4. Conclusion

In summary, This LPG gas leakage measurement scale and detector product is capable of functioning as a technological weighing device that can monitor the remaining volume of gas content in the LPG barrel as well as perform the function of detecting gas leaks around the gas tank. Users can monitor the weight balance of LPG before it reaches a critical level based on the LED indicator flame and the weight reading display on the LCD. The alarm will work when the remaining weight of the gas reaches a critical level and when there is a gas leak. This gives an early warning to users ready to make a new LPG conversion. Notification via SMS to the registered user number about the gas leak can give awareness to the user that there is a gas leak and then make the user to act quickly before a gas explosion that results in a fire. The display of gas balance on the LCD display, LED indicator lights and alarm sounds

can help restaurant operators always be prepared in advance to make new gas cylinders before the problem of running out of LPG gas that can disrupt the cooking process and affect food quality. With this product, restaurant operators can avoid the problem of customers having to wait a long time for operators to find and buy new cooking gas at the last minute. Indirectly, it can also maintain the quality of food delivery service on time to customers. Gas leak detectors that alert notifications via SMS make it important for operators to always be alert to any gas leaks that may occur that could result in a fire in the food premises. LPG traders also benefit from the development of this product when traders no longer have to face pressure from LPG consumers who need to change cooking gas at an immediate rate. This helps traders get the time to always be ready to make LPG delivery service from house to house of the LPG user. The further study for this system should focus on the improvement of efficiency of the product functionality. Among the suggestions are:

- i. Using materials that are less susceptible to fire risk for measurement scale product frames and liquefied petroleum gas (LPG) leak detectors such as stainless steel materials.
- ii. Fix product offset problems by choosing a more stable and good load detector.
- iii. The position of the LCD and LED displays is placed on a conspicuous part.
- iv. Improvements to the position of gas detectors that need to be placed in the area close to the source of gas output.
- v. Minimize the size of the product so that the product can be placed on a gas cooking cabinet space that has a small space size.

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