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IoT-Based Cooking Gas Leak Detection System

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Abstract

The IoT-Based Cooking Gas Leak Detection System aims to warn users to avoid frequent fires due to gas leaks. The objective of this study is to design, develop, and test the functionality of a gas leak detection system. The prototype of the development of this system is based on the Design Thinking model. LCD display, buzzer, and blynk application can help users monitor and warn when gas leakage occurs. This gas detector uses an MQ-5 type gas detector to detect gas leakage readings in the percentage (%) that has been set in the software. The percentage of gas reading will be shown through the LCD display and blynk application while the buzzer will sound if there is a gas reading above 35%. A DC fan will suck in the leaking gas. At the same time, the solenoid valve will automatically close the hose. Arduino IDE software is used as software in this system. The implementation of this project involves testing using gas from a lighter. Expert verification has involved four experts consisting of lecturers and laboratory assistants from the Faculty of Technical and Vocational Education. As a result expert evaluation, shows that the development of a Cooking Gas Leak Detection System Using IOT has achieved the stated objective. Therefore, the development of this system is relevant to be developed to help users in detecting gas leaks.

1. Introduction

In this century, most of the fire accidents that occur in Malaysia are caused by gas leakage due to the negligence of the user while in the kitchen area (Beacon, 2014). This issue has become increasingly concerning as the number of kitchen fires caused by user negligence is on the rise every year, according to the Human Rescue Fire Department (JBPM, 2016). The main factor contributing to these fires is human negligence, as gas leaks often go unnoticed (Joni, 2018). Fire is a rapid oxidation process between combustible materials and gas that can result in light and heat (Abdullah, 2011).

To address this problem, the catering laboratory of University Tun Hussein Onn Malaysia (UTHM) has developed a product to detect gas leaks and provide early warning notifications to prevent fires from claiming lives (Idris, 2012). This product will be placed in the kitchen near the gas cylinder or close to the kitchen. Utilizing various technologies, including Nodemcu, which allows for remote signal transmission, this early gas leak detection product uses a gas sensor to detect Liquid Petroleum Gas (LPG) leaks. This gas is transparent with no color or strong smell but is poisonous. The product will send a simple notification through the Global System for Mobile Communication to warn users if a gas leak is detected. This will help prevent unwanted fires in the workplace, particularly in the catering sector such as hotels, restaurants, and bakeries, and in Higher Education Institutes with catering services.

1.1 Problem statement

According to Kamarudin (2018), gas used for cooking is difficult to detect if there is a leak because it has no smell or color that can be detected with the naked eye. This can lead to kitchen fires caused by gas leaks from the gas barrel pipeline while cooking. To prevent fires, a leak detection system is needed to detect gas leaks and prevent them from spreading. Leaking gas canisters are dangerous if not prevented (Drahman, 2015). Kitchen users should always check the gas tank and pipeline to make sure they are in good and safe condition. Since gas can't easily escape from a closed space, there should be enough ventilation in the kitchen to prevent gas leaks. The kitchen should have an exhaust fan, window, or door to prevent gas leaks from getting worse. Poor ventilation increases the risk of gas buildup, which can lead to sudden fires. Fires, which can cause extensive damage, can be triggered by various factors, including human, technical, or natural causes. In response to these concerns, a leak detection system has been developed for the UTHM catering laboratory, designed to alert users to gas leaks through a buzzer sound and notifications via an application. The system also includes an exhaust fan to help disperse the leaked gas and a solenoid valve to block the gas passage through the hose line, providing a comprehensive safety solution to prevent potential fire hazards.

1.2 Research Objective

The objectives of the developed project are: -

i. To design a prototype capable of detecting cooking gas leaks in the laboratory to enhance user area safety.
ii. To develop an IoT-based cooking gas leak detection system that can send notification messages to a mobile phone and activate a buzzer upon detecting a gas leak in the cooking and catering kitchen.
iii. To evaluate the functionality of the developed system in addressing issues encountered in the FPTV Catering Lab.

By achieving these objectives, the project aims to improve the safety of the laboratory environment and prevent potential hazards caused by gas leaks. The development of a cooking gas leak detection system will provide an effective solution to detect gas leaks and alert users in case of any gas leaks, thereby avoiding any potential risks. The testing of the functionality of the system will help to identify any issues or problems with the system and make necessary improvements to ensure its effectiveness.

2. Methodology

In developing the Gas Leak Detection System product for the Catering Laboratory, the Design Thinking model method was chosen by the researcher. This model was selected because it is a problem-solving method that is carried out in stages, and it is very helpful in the development of a product. The production of quality products that are widely accepted depends on the choice of an appropriate and accurate model.

The five phases of the Design Thinking model used in the development of the Gas Leak Detection System are Empathy, Defining, Ideation, Prototyping, and Testing. The researcher used this model to guide the development of the product and to demonstrate the process flow of producing the Gas Leak Detection System as a methodological method.

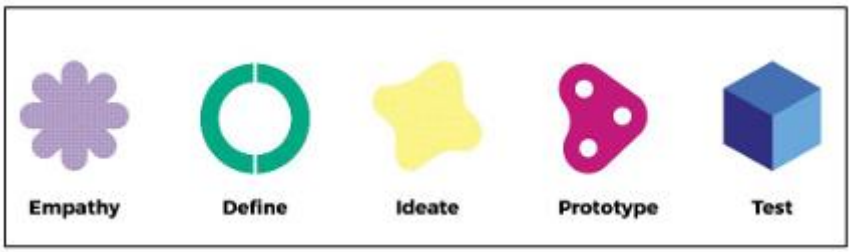


Fig. 1 *The design Thinking Prosses (Curedale,2016)*

2.1 Empathy Phases

In the Empathy phase, preliminary research is done to identify the problems that occur to determine the objective direction of the model to be developed. The method used in this phase is very important because it uses a way of observing, interviewing users, reading articles or journals, and engaging with the problems faced in the context of users' daily lives. The empathy phase in the context of developing a Gas Leak Detection product for the FPTV Catering Laboratory. During this phase, the researcher aims to understand

the user's experience and perspective by conducting interviews and observations. The interviews conducted by the researcher involved speaking with the Laboratory Manager and the Laboratory Assistant to gather important information about the catering laboratory. This information can help in developing a Gas Leak Detection product that meets the needs of the users and improves safety. In addition to interviews, the researcher also conducted observations to gain a better understanding of the catering laboratory's operations. Through observation, the researcher discovered that the catering laboratory has a tight schedule, operating for more than 12 hours a day. The Catering Lab has two sessions, the morning and afternoon, and five cooking rooms that are frequently used by students. The observations also revealed that the risk of gas leakage accidents could occur if safety is not emphasized by users and catering laboratory managers. Overall, the empathy phase is crucial in understanding the user's needs and experience. By conducting interviews and observations, the researcher can gain valuable insights that can help inform the development of a Gas Leak Detection product for the FPTV Catering Laboratory.

2.2 Define Phases

In the Idea phase, it is important to identify the problems that need to be addressed. The scope of the study must be clearly defined to ensure that the project is developed and produced systematically while adhering to the set title and initial objectives. The 5W1H technique can be used to identify user needs and analyze the problem. This approach helps the researcher gain a clearer understanding of the user's needs and the product that needs to be developed. By using the 5W1H technique, the researcher can identify the research problem through the needs and problems of the users. Subsequently, the researcher can determine how to address the problem by answering the questions that arise during the implementation of the product.

2.3 Ideate Phases

In the Idea phase, the researcher uses the brainstorming method, which involves creative thinking and generating brilliant ideas to develop a new product that meets the needs of users based on the information obtained from the Define phase. This phase may take some time, as several aspects must be emphasized in developing the product, including the product's functionality, the improvement of previous versions, the product sketch, the required components, and the cost of production.

Researchers identify the project title, expected problems, and target users. They must determine what users need to overcome gas leakage in the catering laboratory. A gas detection system is required to detect and warn users of gas leaks in the laboratory. To produce a gas detection system for the catering laboratory, researchers can conduct a literature review related to the problem.

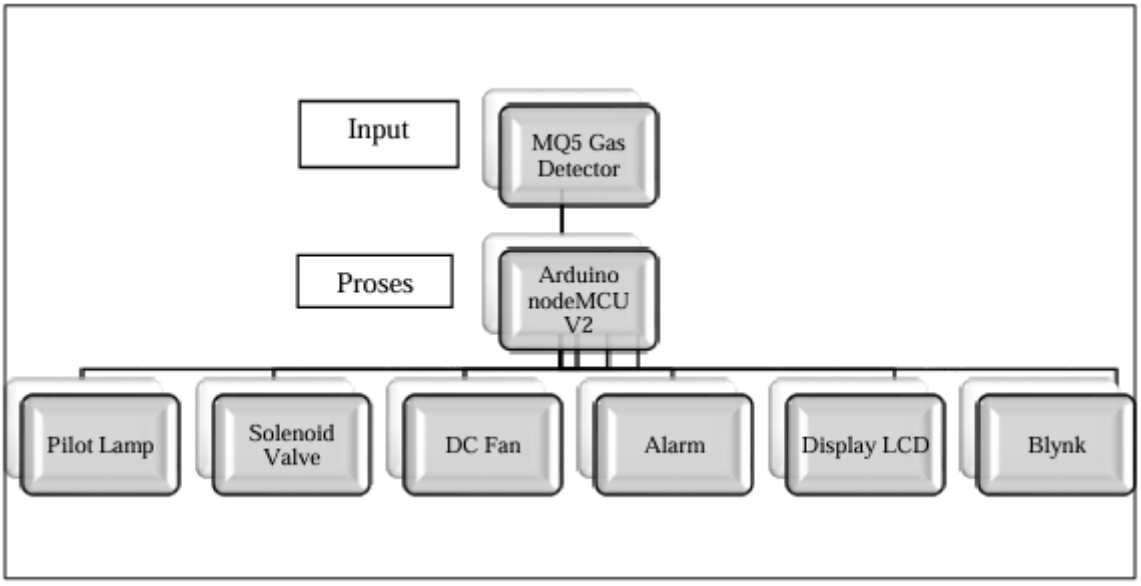
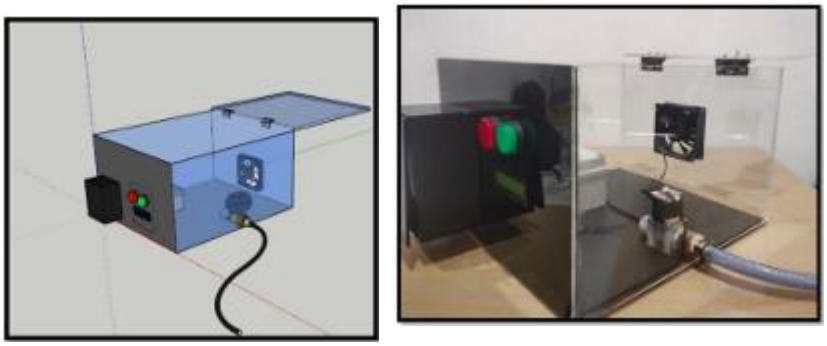


Fig. 2 *Block Diagram*

2.4 Prototype Design Phases

The design phase involves creating a preliminary sketch for the Gas Leakage System prototype to guide the researcher. This phase is systematic and specific, meaning it follows a logical process and considers all aspects of the design. The sketch is made using Sketchup software, making it easier to manage and display the design. The preliminary sketch helps the researcher identify any shortcomings and advantages of the design and determine the appropriate size and materials to use in the final product.



(a) **(b)**

Fig. 3 *Figure description (a) design prototype; (b) Prototype*

2.5 Prototype Testing Phases

During the testing phase, the completed prototype is evaluated to identify any deficiencies and necessary improvements that need to be made. This phase is important to ensure that the product can effectively solve the user's problems. If any issues are identified, the development process may need to go back to earlier phases to address them. The individual components of the system are combined to create a fully functional circuit that meets the project's objectives and goals. Testing is carried out to ensure that the Gas Leak Detection System prototype for the UTHM Catering Laboratory can be operated as intended.

3. Results and Discussion

Prototyping is a crucial step in developing a new product, as it allows for the testing and refinement of electronic components and circuits. To ensure success, accurate research is needed to inform the design process. For example, a prototype designed for cyclists needs to be user-friendly and safe, with a reliable safety system that makes riders feel secure. Testing the main components of a product is a key part of the prototyping process, as it allows developers to identify and address any issues before the product is released to the market. As such, prototyping is a critical aspect of product development, allowing for the creation of safe and effective products.

3.1 Analysis Sensor MQ5: Detection of gas leak

The MQ-5 gas detection circuit is designed to detect the presence of gas leaks and measure the concentration of the gas in parts per million (PPM) over both long and short distances. The gas sensor used in this circuit provides both analog output (AO) and digital output (DO), but in this system, the analog output is used to measure the PPM value based on the set program limits.

The gas sensor detects the presence of gas in the environment, and this information is transmitted through the circuit using the analog output. The circuit can then use this information to determine the concentration of gas in the environment and alert the user if it exceeds the set limits.

Gas detectors are commonly used in industrial and commercial settings to monitor for the presence of hazardous gases and to ensure the safety of workers and occupants. It is important to regularly maintain and calibrate gas detection systems to ensure they are functioning properly and accurately detecting the presence of gas leaks.

Table 1: *Gas Detection Functionality Test Results: Undetected*

Item	*Gas Reading (%)*	*Pilot Lamp (Green)*	*Pilot Lamp (Red)*	*Solenoid Valve*	*Exhaust Fan*	*Buzzer*
1	10%	✓	X	Open Gas	Off	Off
2	15%	✓	X	Open Gas	Off	Off

3	20%	✓	X	Open Gas	Off	Off
4	25%	✓	X	Open Gas	Off	Off
5	30%	✓	X	Open Gas	Off	Off

Table 2: *Gas Detection Functionality Test Results: Detected*

Item	Gas Reading (%)	Pilot Lamp (Green)	Pilot Lamp (Red)	Solenoid Valve	Exhaust Fan	Buzzer
1	10%	X	✓	Block Gas	On	On
2	15%	X	✓	Block Gas	On	On
3	20%	X	✓	Block Gas	On	On
4	25%	X	✓	Block Gas	On	On
5	30%	X	✓	Block Gas	On	On

3.2 Analysis Sensor MQ5 : Function

The testing of components, processes, and prototype outputs was conducted as planned before prototype development, and the results demonstrate that each process is functioning properly. Specifically, the power supply switch provides power to the components to operate, while both pilot lights and the DC fan spinning indicate successful Wi-Fi connection. The LCD displays the percentage reading of the gas value, with green pilot lights lighting up from 0 to 34% to indicate a safe level. When the gas percentage reading exceeds 35%, the red pilot light illuminates to alert the user. The LCD displays the gas reading, and the DC fan operates to extract gas from the prototype. Additionally, the valve blocks the gas, and the user receives a notification on the Blynk application when there is an excessive presence of LPG gas in the prototype. Finally, users can manually control the DC fan from the Blynk app. Since there is a potential for malfunctioning when producing a prototype of a Cooking Gas Leak Detection System Using IoT, the researcher conducted testing on the prototype system five times to ensure its proper functionality. Table 3 presents the results of the functionality testing of the Prototype Cooking Gas Leak Detection System Using IoT.

Table 3: *Functionality test results for detector and applications*

Testing / *Trial*	*1*	*2*	*3*	*4*	*5*
LCD I2C	Not Function	Function	Not function	Not function	Function
PILOT LAMP	Function	Function	Function	Function	Function
RESET BUTTON	Function	Function	Not function	Not function	Function
BUZZER	Not function	Function	Not function	Function	Function
RELAY	Not function	Function	Not function	Function	Function
SENSOR	Not function	Function	Function	Not function	Function
EXHAUST FAN	Function	Not function	Function	Not function	Function
SOLENOID VALVE	Function	Function	Function	Function	Function

The researcher has analyzed the problem according to the table. After evaluating the prototype of the Cooking Gas Leak Detection System Using IoT, it was discovered that the circuit was not functioning properly due to errors in the program, loose cable connections, and an insufficient power supply during the initial testing. As a result, the researcher repaired the circuit, ensuring that all components and cables were properly connected, and confirmed that it was in good condition to function as desired during the subsequent testing.

3.3 Discussions

In this section, the result was discussed based on the objectives that have been stated for this study: -

3.3.1 Designing a Prototype Cooking Gas Leak Detection System

The paragraph discusses the design phase of a prototype cooking gas leak detector system. The design analysis is based on various aspects to meet user needs and objectives, including problem and product analysis. The product analysis considers existing gas leak detection systems on the market, which led to the development of a Cooking Gas Leak Detection System Using IoT for the FPTV Catering Laboratory. The design process involves software such as Sketch Up and Proteus to ensure component size and arrangement. The circuit design includes electronic components such as nodemcu microcontroller circuits, alarms, and LCD displays, with the MQ2 detector used due to its sensitivity to LPG, natural gas, and coal gas. The experts confirm the prototype design, but they note that it may be less durable. Overall, the prototype design achieves the researcher's first objective.

3.3.2 Development of Gas Leak Detection System Prototype

During the system development phase, which is based on the design planned in the previous phase, the hardware and software parts are divided into several parts. The circuit box of the product is made of acrylic due to its easy shaping and transparency for visualizing the interior. For the software, Arduino IDE is used to program and develop the electronic circuits while Proteus is chosen to develop the circuit. Sketch Up software is used to develop a prototype of the system, which provides a realistic image of the product to be developed. The Cooking Gas Leak Detection System Using IoT was developed to detect LPG gas leaks in the catering laboratory. Unlike previous gas leak detectors that only provide notices such as SMS, buzzer sound, and LCD display, this system has an additional IoT feature that enables users to receive notifications on their smart devices and control the exhaust fans remotely. The system is designed to warn users with a buzzer and an LCD display and automatically cut off the gas supply to the kitchen. The DC Fan (exhaust fan) is used to suck the leaked gas from the laboratory. The development of this system prototype has achieved the second objective, which is to detect gas leaks and cut off gas supply automatically while notifying users on their smart devices.

3.3.3 Testing the Prototype Functionality of Gas Leak Detection System

According to Jasmi, (2015), the evaluation and verification of the developed product is carried out based on the factors of functionality, user-friendliness, and user acceptance. Products A, B, and C each offer distinct advantages and functions, and the developed prototype integrates the features of all these products, considering both their functionalities. As is known, this prototype develops two functions in one product, which is to detect LPG gas leaks and maintain safety from fire, so the power supply included is different where the power supply for the solenoid valve circuit and DC Fan is 12V and the MQ5 detection circuit is 3V. The gas leak detection circuit will start operation after the power supply is turned on and the internet connection is successfully connected to the programming. Next, it will continue to display the gas reading on the LCD and in the Blynk application. Then if there is an excessive gas reading the user will get a notification to the smartphone.

The functionality of the prototype has been developed to evaluate whether it performs as intended or not. This system is tested by using lighters and gas canisters in a closed room. When a gas leak is detected, the buzzer will produce a warning sound and the user will receive a notification stating the gas percentage, then the DC fan will turn on and the solenoid valve will automatically shut off the gas supply from entering the kitchen. In addition, the distance and space play a role in affecting the gas detector to detect the presence of leaking gas because the gas needs a little time to fill the cooking space depending on the size of the room. This process is done to facilitate the process of solving problems that arise during prototype development.

4. Conclusion

Additionally, the implementation of this prototype is expected to provide various benefits for users, including improved safety in the kitchen, reduced risk of fire and explosion due to gas leaks, and increased peace of mind knowing that a gas leak detection system is in place. It is important to note that the prototype of the Cooking Gas Leak Detection System Using IoT is just a starting point for further development and improvement. Researchers and developers can continue to build on this prototype by incorporating new technologies and enhancing the system's capabilities. This can include adding features such as remote monitoring, automatic shut-off systems, and mobile notifications to alert users in case of a gas leak. Overall, the Cooking Gas Leak Detection System Using IoT has the potential to make a significant impact on kitchen safety and the development of this prototype is a step in the right direction towards a safer cooking environment.

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