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Design of Early Fire Detection System in Tobacco Oven Based on Internet of Things (Case Study: East Landah Praya Village)

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Abstract **A tobacco oven is a building measuring 4.5 x 4.5 meters that are used to bake freshly harvested tobacco leaves and can accommodate up to 5-7 shelves. The oven building is equipped with 2 bottom vents and 2 top vents which function as temperature and humidity regulators by opening or closing the vents. Tobacco oven techniques in Lombok itself can not be said to be safe, it is proven that fires in tobacco ovens often occur lately. One of the causes of tobacco oven fires is due to the presence of tobacco leaves falling into the furnace so that the fire quickly grabs the tobacco in a semi-dry state, in addition, due to the lack of use of safety equipment above the ignition furnace, the fallen dried tobacco leaves can immediately burn. Based on these problems, research entitled "Design of Fire Early Detection System in Tobacco Oven Based on Internet of Things was made (Case Study: East Landah Praya Village)". This early fire detection system is a system that is connected to the internet network that can provide warnings in the form of notifications automatically through the Telegram application. Making this system requires several components including Wemos D1, DHT22 sensor, infrared flame sensor, MQ-135 gas sensor, and buzzer.**

Key words**: Tobacco oven; infrared flame sensor; MQ-135 gas sensor; buzzer; telegram.**

I. INTRODUCTION

Tobacco is one of the plantation crops commonly used as raw material for making cigarettes. In Indonesia, the development of tobacco production increases every year, especially in the West Nusa Tenggara (NTB) region. West Nusa Tenggara is one of the largest tobacco-producing areas, with a harvested area of 24972.29 Ha, which was recorded at 41313.68 tons of tobacco produced in 2020[1]. One of the places in West Nusa Tenggara which is a producer of tobacco is Central Lombok. In Central Lombok itself, tobacco has been a mainstay commodity for years. In 2019 the Tobacco Excise Revenue Sharing Fund (DBH-CHT) obtained by Central Lombok was IDR 48.2 billion[2]. In 2020 Central Lombok produced as much as 20224.32 tons of tobacco, which can be said to be half of the total tobacco production in West Nusa Tenggara[1]. Based on these data, it shows that tobacco plantation activities are one of the major contributors to the economy.

Generally, tobacco plants are planted at the end of the rainy season when the intensity of the rain has decreased and is harvested during the dry season. Tobacco that has been harvested can be sold directly to cigarette companies, however, to get a higher price, farmers usually bake the tobacco first. A tobacco oven is a way to reduce the moisture content in it. To remove the moisture content in wet tobacco leaves, hot air is used which is blown through the flame. Generally, in Lombok, tobacco ovens are built with a size of 4.5 x 4.5 meters which can accommodate 5-7 shelves. The oven building is equipped with 2 bottom vents and 2 top vents that function as temperature and humidity regulators by opening or closing the vents.

Tobacco oven techniques in Lombok itself can not be said to be safe, it's proven that fires in tobacco ovens often occur lately. On August 4, 2021, in East Praya District, an oven containing 7 tons of tobacco burned down[3]. On August 15, 2021, in East Praya Subdistrict, 5 tons of tobacco that had been oven-baked for three days was completely burned[4]. On September 27, 2021, a tobacco oven containing 7 tons of tobacco caught fire again causing a loss of around IDR 50 million[5]. One of the causes of tobacco oven fires is tobacco leaves falling into the furnace so that the fire quickly grabs the tobacco in a semi-dry state in addition, due to the oven condition being too hot over 80° Celsius which is the ideal temperature for a tobacco oven and the lack of use of safety equipment in the oven. The top of the ignition stove makes the fallen dried tobacco leaves burn immediately. Tobacco oven which is carried out 24 hours a day for one week also makes tobacco farmers lack rest so that they lose focus and the human error occurs.

Incidents of fires in tobacco ovens can be minimized if it's responded quickly so that the tobacco being baked is not completely burned out by providing early warning of fires. In this case, the Internet of Things (IoT) is one solution that can be used for the early detection of fires in tobacco ovens. By utilizing the Internet of Things (IoT) tobacco farmers not only get a warning in case of a fire but can also monitor the temperature situation of the tobacco oven itself so that the oven process can be more controlled.

Based on the problems described above, research entitled "Design of an Early Fire Detection System in a

Tobacco Oven Based on the Internet of Things was conducted (Case Study: East Landah Praya Village)". This fire early detection system is a system that is connected to the internet network that can provide warnings in the form of notifications automatically through the telegram application. Based on a survey conducted with six respondents in Landah Village, the majority of tobacco farmers use smartphones with the Android operating system which supports the application of the Telegram application itself. In addition, the use of the Telegram application by tobacco farmers is considered easy and familiar, because it is not much different from the Whatsapp messenger application that they usually use daily. The Telegram application itself has a bot feature, this bot feature can be used as a fire early warning media or as a monitoring medium for tobacco ovens. The Whatsapp application also has a bot feature but it is different from the Telegram application, the Whatsapp application is not more flexible than the Telegram application because, to register a bot on the Whatsapp application it requires a phone number, so when a user wants to switch from one device to another it will be difficult because the bot registered already tied to a certain number, in contrast to the Telegram application which does not require a phone number. As for making this system, it requires several components including Wemos D1 as the microcontroller of the system, DHT22 temperature sensor, infrared fire sensor, MQ-135 gas sensor, and buzzer (alarm). The existence of an early detection system for fires in tobacco ovens is expected to assist tobacco farmers in detecting if there are indications of fire and facilitate monitoring of tobacco ovens which requires farmers to monitor 24 hours a day for 1 week.

II. Study Literature

In the following study, researchers designed a system that is able to monitor and provide information on forest fires early. There are two controllers used in the system, which are Arduino Uno R3 and GSM/GPRS Shield SIM900. The system works using an LM35 temperature sensor and a fire sensor that works in real-time and can be monitored via the website. When the LM35 temperature sensor detects a temperature with conditions > 45^{o} C, the system provides a red indicator on the website, if the flame sensor detects the presence of a fire, the GSM/GPRS Shield SIM900 will automatically send an SMS message as a fire notification to the user. The system was tested by placing the system hardware 30 cm away from a fire source. The results show the system can work well and can provide fire notifications in just a few minutes (≤5 minutes) however, the ability of the flame sensor used is not enough to cover a large area because the system uses a 1-point flame sensor model that only can detecting fire with a limited degree[6].

The following research is a system that can detect indications of a fire in a room. The way this system works is similar to the system in previous study, this system works by activating a mini pump as a driving motor to flow fire extinguishing water when a fire is detected and a buzzer as a warning alarm, however this system uses an SMS gateway as a digital information tool by using SIM800L module that works by sending an SMS warning as an early warning in the event of a fire or to see the condition of the room[7].

The following research is a system that can detect fires and automatically send fire alerts to homeowners via the Telegram application. The system used to detect fires uses NodeMCU esp-32 as a microcontroller and three sensors to detect indications of a fire in the house, three sensors used are Flame IR sensor (fire sensor), MQ-2 sensor (smoke sensor), and sensor DHT11(temperature sensor). The three sensors were tested to determine the level of accuracy and sensitivity of each sensor. The output data obtained from the three sensors is processed in an algorithm that has been designed and produces output in the form of status notifications for fire indications. In conclusion, it is shown that the system can work well, and for testing the performance of the system the results obtained reach 90% [8].

The following research is a fire detection system in a building that can provide information to related parties regarding the location of fires via the web. This system works by utilizing two types of sensors, namely the MQ2 Smoke sensor and the LM35 temperature sensor, and one bell as a warning alarm. Both sensors were tested to know whether the sensors were working as expected. For testing on the LM35 temperature sensor, an accuracy of 98.9% was obtained after the difference in measurements with the thermometer was made and for the MQ-2 smoke sensor, calibration was carried out so that the sensor could work accurately. In the system there are 3 types of conditions to determine the state of the building, namely: SAFE conditions: Temperature <350C and smoke <500ppm, STANDBY conditions: Temperature >=350C – <450C and smoke >=500ppm – <1000ppm, and DANGER conditions: Temperature > =450C and Smoke >=1000ppm. The percentage of the resulting system is 99.3% [9].

The following research is a system that can monitor the temperature in the tobacco oven. This system uses the website as a digital medium for monitoring the temperature of the tobacco oven which can be accessed via gadgets and mini monitors to monitor the temperature directly. Several other components used in the system are the DHT11 temperature sensor and NodeMCU(esp8266) as a microcontroller. This system helps tobacco farmers in monitoring the temperature conditions of the tobacco oven so that it remains stable and the maximum drying results of tobacco are obtained. The test results show the DHT11 sensor works well with the level of system accuracy in monitoring the temperature is passably high, namely ± 96% [10].

Based on several studies related to fire detection systems are widely applied to homes and buildings by utilizing temperature sensors and flame sensors to detect fire indications. In this study, the authors designed a fire detection system in a tobacco oven that did not allow for a temperature sensor as the only fire detection sensor due to the high-temperature oven condition. The main sensor uses a flame sensor and smoke sensor as a fire detector and a temperature sensor for temperature monitoring which can be monitored through the Telegram application by utilizing the Telegram bot.

The Internet of Things (IoT) is a system consisting of smart devices, including sensors, actuators, and microcontrollers, which allow for the automatic exchange of information and communication[11]. Internet of Things (IoT) can also be interpreted as advanced technology that can communicate objects with each other around them through an Internet network. With this ability, the Internet of Things (IoT) will make it easier for human activities to carry out various daily activities. All activities can be done practically and with a control system, life will be more effective and efficient. One application of the Internet of Things is in home automation, Internet of Things (IoT) devices can be used to monitor and control mechanical, electrical, and electronic systems at home remotely via the internet as long as there is a good internet network.

Wemos D1 is a wifi-based module development board from the ESP8266 family that has compatibility with the Arduino IDE, so you can use the Arduino IDE to create or compile programs and download them to this board. Wemos was created as a solution to the high cost of another microcontroller-based wireless system. By using Wemos, the costs incurred to build a Wi-Fi system are cheaper and its ability to provide Wi-Fi connectivity facilities is easy and the memory used is very large, namely 4 MB[12]. The characteristics of the Wemos D1 include:

- Microcontroller : ESP-8266 32-bit
- Clock Speed : 80MHz and up to 160MHz
- USB Converter : CH340G
- Operating Voltage : 3.3V
- Flash Memory : 4MB
- Digital I/O : 11
- Analog Inputs : 1
- Communications : I2C, Serial, SPI
- WiFi : Built-in

The DHT22 sensor or also known as AM2302 is a sensor capable of measuring the temperature and humidity of the surrounding air. This sensor is considered more accurate and precise in terms of measurement compared to DHT11. DHT22 is a sensor with output in the form of a digital signal and has 4 pins consisting of power supply, data signal, null, and ground[13]. The characteristics of the DHT22 sensor include:

- Power supply range: 3,3 – 6 Volt DC
- Current consumption when measuring between 1 to 1.5 mA
- Output signal: Digital signal via 1-wire bus
- Humidity detection range: 0-100% RH (accuracy ±2% RH)
- Temperature detection range: -40o ~ +80o Celcius (accuracy ± 0,5o C)

A fire sensor or Flame sensor is a sensor capable of detecting the presence of fire. Infrared sensors can read wavelengths with a range of waves ranging from 760 nm-1100 nm. Infrared is the color of visible light with a wavelength of about 700 nm to 1 mm. While ultraviolet light emits light with a wavelength of about 300 nm - 400 nm. This sensor can detect infrared waves emitted by fire, so the sensor can be used as a fire detector[14]. The characteristics of this infrared flame sensor include:

- Spectrum wave range : 760nm ~ 1100nm
- Detection angle : 0 - 60 degrees
- Power supply range : 3.3V ~ 5.3V
- Working temperature range : -25℃ ~ 85℃
- Size : 27.3mm * 15.4mm

The MQ-135 sensor is a sensor that monitors air quality to detect ammonia gas (NH3), sodium-(di)oxide (NO2), alcohol/ethanol (C2H5OH), benzene(C6H6), carbon dioxide (CO2), sulfur gas/sulfur hydroxide (H2S) and smoke/other gases in the air[15]. The characteristics of the MQ-135 sensor include:

- The power supply source uses a voltage of 5V
- • Using ADC with 10-bit resolution
- 1 ON/OFF control output line available
- Input/Output pins compatible with TTL and CMOS voltage levels
- Signal output indicator instructions
- Dual signal output (analog output, and TTL level output)
- Analog Output with increasing concentration, the higher the concentration, the higher the voltage
- Fast response recovery[16].

A buzzer is an electronic component that can convert electrical signals into sound vibrations. The buzzer usually used as an alarm signal for a condition. The buzzer is an electronic component that is classified as a transducer. The buzzer has two legs, positive and negative. To use it we can give a positive and negative voltage of 3 - 12V[17].

Telegram is a messaging service application based on an open-source platform built by Russian Pavel Durov and released in 2013. Telegram is a cloud-based application that has an encryption system that provides end-to-end encryption, self-destruction messages, and an automated multi-data center infrastructure, so messages and content sent on the Telegram application are completely safe from third parties, even from Telegram. The ease of access provided by Telegram which can run on almost all platforms makes it easy for administrators to build a notification system by utilizing the Application Programming Interface (API) facility provided by Telegram through bots that can be used to send messages automatically. The cloud base on Telegram allows for a much faster delivery process and large storage media[8].

Arduino IDE is an open-source software used to program Arduino boards. In this software, a programming sketch is carried out in other words the Arduino IDE is used as a programming medium on the board that you want to program. This software runs on Windows, Mac OS X, and Linux. Based on Processing, Avr-GCC, and other open source software[18].

A tobacco oven is a tobacco drying device in the form of a building with brick walls like a house with a general size of 4.5m x 4.5m. The oven has a stove for burning wood or gas, the heat from the stove is channeled through iron pipes located below and around every corner of the tobacco oven. The tobacco oven is also equipped with two bottom vents and two top vents that function as temperature and humidity regulators and one door for access to and out of the oven. In the tobacco oven, the shelves used to store the leaves are built using bamboo with 5-7 shelves and arranged upwards.

III. Method

A. Implementation Plan

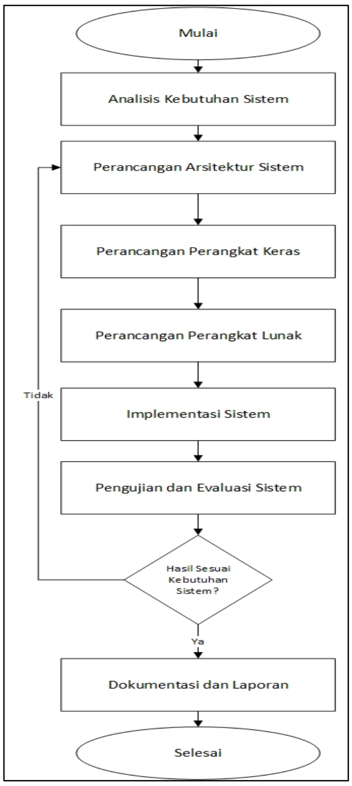

Fig. 1. Implementation plan

Fig. 1 is a flow chart of the design of a Fire Early Detection System in a Tobacco Oven Based on the Internet of Things. The following is an explanation of each stage.

1. Analysis of system requirements, at this stage will be explained the needs needed to build a Fire Early Detection System in Tobacco Ovens Based on the Internet of Things.
2. Designing the system requirements, at this stage the architectural design and workflow of the system to be built will be carried out, namely the Fire Early Detection System in Tobacco Ovens Based on the Internet of Things.
3. Software design, at this stage a simple Telegram application will be designed to monitor conditions in the tobacco oven.
4. Implementation of the system, at this stage the preparation of the Fire Early Detection System in the Tobacco Oven Based on the Internet of Things will be carried out and system integration with the Telegram application by utilizing the Telegram bot API.
5. Testing and evaluation, at this stage a test will be carried out on the system that has been created and an evaluation of the results of system testing will be carried out, if the system runs according to the results that have been analyzed it will proceed to the next stage, namely the documentation and report stage, but if it does not match with the results of the analysis that has been done, improvements will be made at the device design stage.
6. Documentation and reports, at this stage a report will be prepared from the results of system testing and evaluation that have been carried out.

B. System Requirements Analysis

In the system requirements analysis stage, an analysis of the needs of the Fire Early Detection System in the Tobacco Oven Based on the Internet of Things will be carried out. The analysis carried out includes an analysis of the needs for tools and materials including the following:

1. Laptop/PC used to code programs with Intel Core i5-9300h specifications with Windows 11 operation.
2. 1 DHT22 sensor which is used to determine the temperature and humidity in the tobacco oven.
3. 1 MQ-135 sensor which is used to detect the smoke density in the tobacco oven.
4. 1 infrared flame sensor which is used to detect the presence of fire in the tobacco oven.
5. 1 Wemos D1 is used as a microcontroller.
6. 1 buzzer.
7. Arduino IDE Software
8. Telegram application.

C. System Architecture Design

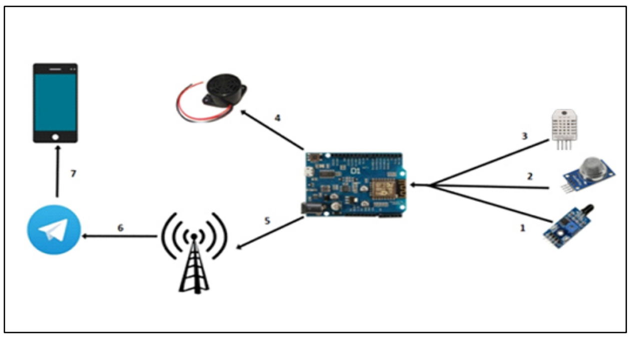

Fig. 2. System architecture

Some of the processes in Fig. 2. include the following:

1. The first process is an infrared flame sensor that is used as a tool to detect if there is a fire in the tobacco oven.
2. The second process, namely the MQ-135 smoke sensor is used as another indicator to detect fires by detecting the ammonia content in the smoke in the tobacco oven.
3. The third process is the DHT22 temperature sensor is used as a tool to measure the temperature value in the

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tobacco oven whose data is used to monitor the temperature of the tobacco oven.

4. The fourth process is the Wemos D1 microcontroller taking data from the infrared flame sensor and the MQ-135 temperature sensor and sending a command to sound the buzzer if there is an indication of fire according to the data obtained.
5. The fifth, sixth, and seventh processes are the Wemos D1 microcontroller process sending fire notifications or temperature data to the Telegram application by utilizing the Telegram library and HTTP API tokens so that they can be integrated with Telegram bots as monitoring media.

D. Hardware design

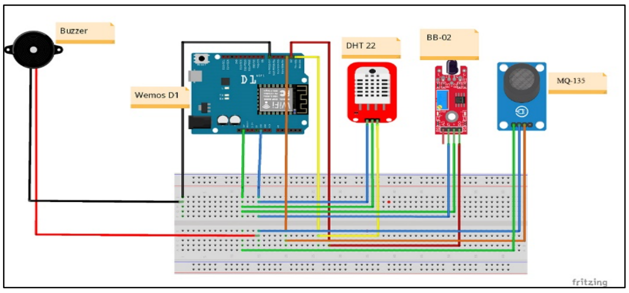

Fig. 3. Hardware design

At the hardware design stage, the hardware materials to be used will be compiled, namely the Wemos D1 microcontroller and electronic modules in the form of infrared flame sensors, DHT22 sensors, MQ-135 sensors, and buzzers.

E. System Design in Tobacco Oven

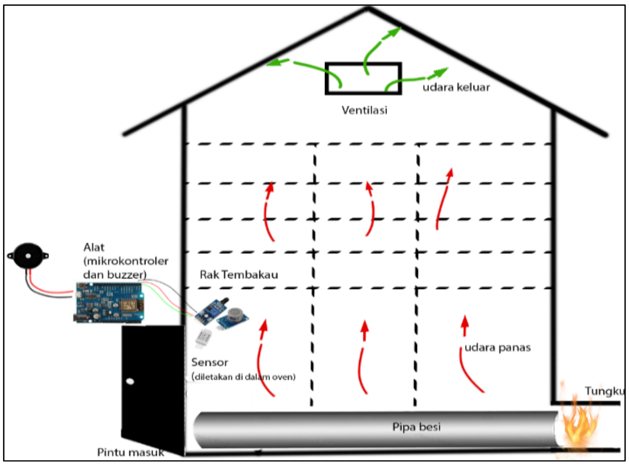

Fig. 4. System design in the tobacco oven

Fig. 4 is a design of the placement of the tool in the tobacco oven which will be placed in the best position so that it can work optimally. Some of these tools are:

1. The microcontroller will be placed outside of the tobacco oven to avoid the heat by the.
2. The buzzer that is used as a warning alarm for an indication of fire will be placed outside the tobacco oven together with the microcontroller.
3. The infrared flame sensor will be placed inside the tobacco oven precisely against the wall and about 30 cm down from the bottom tobacco rack.
4. The MQ-135 sensor will be placed in the tobacco oven against the wall and about 30 cm up from the lowest tobacco rack.
5. The DHT22 sensor will be placed in the same position as the MQ-135 sensor.

F. Software Design

At the software design stage, a Telegram bot will be made by utilizing BotFather so that tokens are obtained to access the HTTP API which can be used to integrate the system with the Telegram application.

E.1. Use Case Diagram

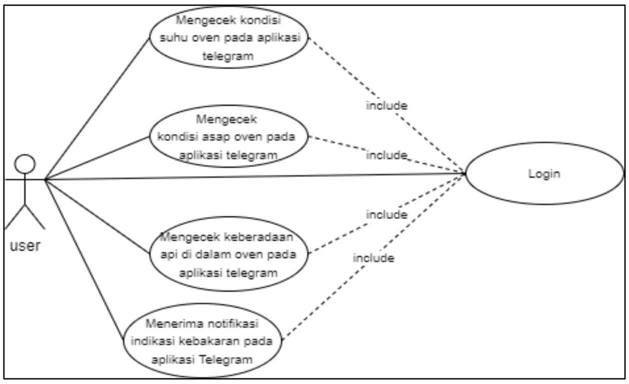

Fig. 5 Use case diagram

In the Use Case diagram of the system, there are two activities and one actor, namely the user. Users here can perform activities to see fire conditions, temperature, and ppm smoke in the tobacco oven and receive notifications if there are indications of a fire in the oven. To perform these activities, the user must first log into the system on the Telegram application.

IV. Results and Discusion

A. Hardware Implementation

Overall there are 5 main components, namely Wemos D1, DHT22 sensor, MQ-135 sensor, infrared flame sensor, a buzzer (alarm), and Wemos D1 microcontroller. These 5 components will be designed into a single unit that has their respective duties. Wemos D1 functions as a microcontroller that can control all components where later the components used will work according to orders from Wemos D1, the DHT22 sensor functions as a sensor that can take temperature readings in the tobacco oven, the MQ-135 sensor functions as a sensor capable of reading ammonia levels on the smoke in the tobacco oven, the infrared fire sensor functions as a sensor capable of detecting the presence of fire in the tobacco oven and the buzzer (alarm) functions as a warning alarm when there is an indication of fire in the tobacco oven. Below is the overall result of the hardware design.

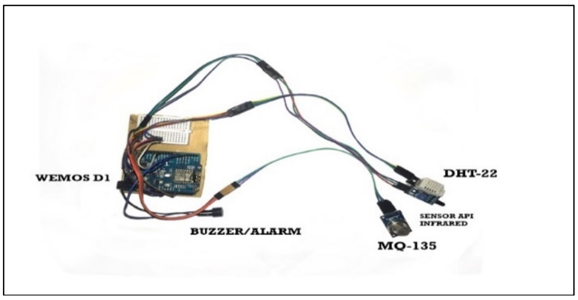

Fig. 6. Hardware design

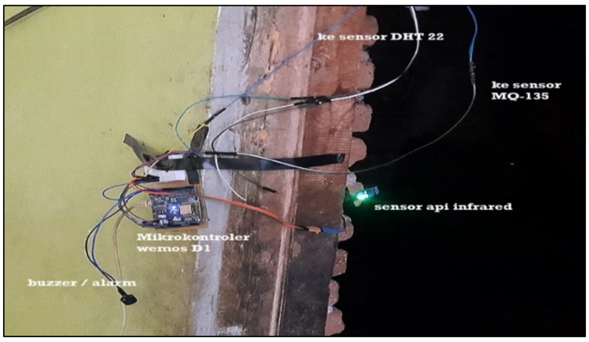

Fig. 7. hardware system on tobacco oven

B. Realization the Use of Telegram Application

The use of the Telegram application as software for monitoring the state of the tobacco oven can provide notifications regarding fire indications and conditions including temperature conditions, smoke conditions, and the presence of fire. The following is the interface of the Telegram application as system software utilizing a Telegram bot with the name Tobacco Oven in Fig. 10.

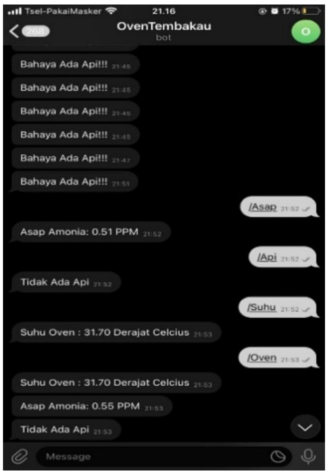

Fig. 8. System interface on the Telegram application

C. Overall System Testing

C.1. Infrared Flame Sensor Testing

Infrared fire sensor testing is to determine whether the sensor can read the presence of fire in the tobacco oven, as well as to test the sensitivity of the sensor towards the presence of fire at certain distances and certain intensities. In this test, 3 fire intensities were used, namely big, medium, and small. Fig. 11 to 13 is an illustration of the intensity of the fire used and the test results.

Fig. 9. Big fire intensity

Fig. 10. Medium fire intensity

Fig. 11. Small fire intensity

TABLE I. SYSTEM TEST RESULT

No	Distance straigh from sensor (in line)	Distance from sensor (sideway)	Fire intensity	Status	
				Detected	Not Detected
1	± 100cm	0cm	Small	✓	
2	± 100cm	0cm	Medium	✓	
3	± 100cm	0cm	Big	✓	
4	± 100cm	± 50cm	Small		✓
5	± 100cm	± 50cm	Medium		✓
6	± 100cm	± 50cm	Big		✓
7	± 100cm	± 100cm	Small		✓
8	± 100cm	± 100cm	Medium		✓
9	± 100cm	± 100cm	Big		✓
10	± 200cm	0cm	Small		✓
11	± 200cm	0cm	Medium	✓	
12	± 200cm	0cm	Big	✓	
13	± 200cm	± 50cm	Small		✓
14	± 200cm	± 50cm	Medium		✓
15	± 200cm	± 50cm	Big	✓	
16	± 200cm	± 100cm	Small		✓
17	± 200cm	± 100cm	Medium		✓
18	± 200cm	± 100cm	Big	✓	
19	± 400cm	0cm	Small		✓
20	± 400cm	0cm	Medium		✓
21	± 400cm	0cm	Big	✓	
22	± 400cm	± 50cm	Small		✓
23	± 400cm	± 50cm	Medium		✓
24	± 400cm	± 50cm	Big	✓	
25	± 400cm	± 100cm	Small		✓
26	± 400cm	± 100cm	Medium		✓
27	± 400cm	± 100cm	Big	✓	

Based on the test shown in Table I, 27 samples were taken and can be concluded that the distance, angle, and intensity of the fire affect the results of the infrared flame sensor readings on the fire in the tobacco oven. Based on the data obtained, it shows the infrared flame sensor can detect the presence of fire in the tobacco oven up to ± 400 cm straight from the sensor and ± 100cm sideways with a large fire intensity while with medium and small fire intensity at that distance the fire is not detected. The percentage for the experiment for small fire intensity after the calculation was obtained 11.1%, for medium fire intensity was 22.2% and for large fire intensity was 77.7% based on this it can be concluded that a single channel infrared flame sensor can detect fire with The intensity of the fire is large against the distance in the tobacco oven quite well but not for certain angles so that it can be said that the one-channel infrared flame sensor has not been able to detect the presence of fire at every corner in the tobacco oven.

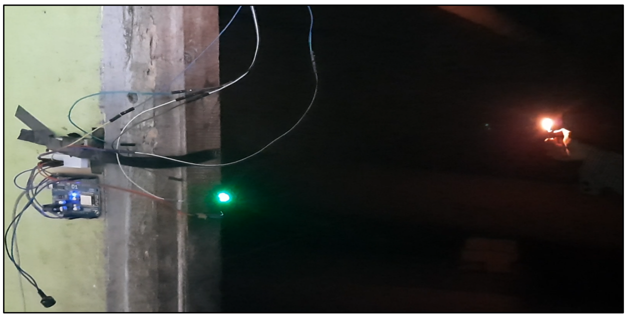

Fig. 12. Infrared flame sensor testing

C.2. MQ-135 Smoke Sensor Testing

The MQ-135 sensor test is to determine whether the sensor could read the changes in ppm of ammonia in the air contained in the tobacco oven so that the ppm value when the oven was working could be used as a benchmark to determine indications of a fire in the tobacco oven. The MQ-135 sensor in the application to detect ppm levels of ammonia in the air needs to be calibrated. The first thing to do is look for the specifications of the MQ-135 sensor on the MQ-135 sensor datasheet. The MQ-135 sensor has RL (Load Resistance) that located between VRL and the Ground. On the MQ-135 sensor module, the load resistance installed is an SMD resistor with code 103 h has a resistance value of 10K ohms. After getting the RL (Load resistance) value, then look for the sensor sensitivity value to ammonium (NH4) which is represented by a purple line on the MQ-135 sensor sensitivity characteristic graph and the clean air value is represented by a dark blue line can be seen from Fig. 4.9, based on that, a comparison value of sensor sensitivity will be obtained to the value of clean air (RS) and air containing ammonia (RO), the comparison value obtained based on the sensor sensitivity graph on the RS/RO datasheet is 3.6.

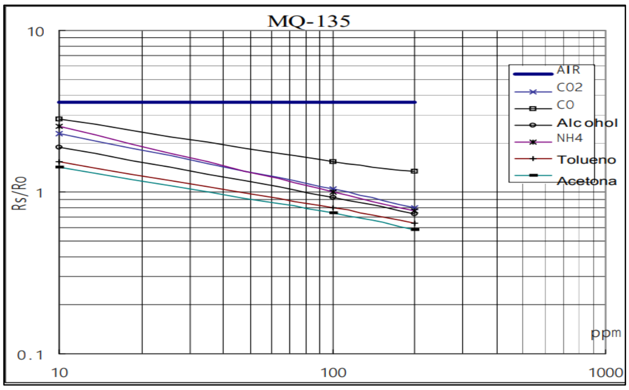

Fig. 136. MQ-135 sensor sensitivity characteristic graph

After the value of RS/RO is known, then look for the value of RS where to find the value of RS using the following equation.

$$RO = RS/3{,}6 \tag{1}$$

$$\text{Resistance Sensor } (Rs) = (Vc/VRL - 1) * RL \tag{2}$$

Based on this equation, known that Vc is the source voltage with a value of +5Volt, then it is known that the RL (Load resistance) is 10K ohms, and to find the VRL (Voltage Resistance Load) value using the following equation

$$\text{Voltage Resistance Load (VRL)} = \text{analog value of sensor} * (5.0/1023.0) \tag{3}$$

From the Eq. 3, the process will be carried out using the Wemos D1 Microcontroller on the Arduino IDE software. The calculation of this ratio aims to get the sensor resistance value in ammonia gas, which is 17. The calculation of the RO value itself can vary in each condition, to get the optimal RO value, preheating or preheating the MQ-135 sensor for 1 hour.

$$log\ (y) = m * log(x) + b \tag{4}$$

The Eq. 4 is a representation of the logarithm between RS/RO and PPM. The next step will be to calculate the gradient and the intersection of the purple line which is a characteristic of the sensitivity of the MQ-135 sensor to ammonia by determining the points (x1,y1) and (x2,y2) in Fig. 4.9, the purpose of determining this point is to find the values of m and b. Based on the graph in Fig. 4.9, the point values (x1, y1) and (x2, y2) are (19) and (100) so the m value can be calculated with the Eq. 5.

$$m = [log(y2) - log\ (y1)]/[log(x2) - log(x1)] \tag{5}$$
$$m = log\ (½) / log\ (100/9)$$
$$m = -\ 0{,}417\ m$$

The value of m has been obtained then the value of b can be calculated by the Eq. 6.

$$b = log(y) - m * log(x) \tag{6}$$

$$b = log\,(1.55) - m * log\,(40)$$
$$b = 0{,}858$$

From all the values obtained, calculations will then be carried out to find the value of the PPM with the Eq 7.

$$PPM = 10\text{^}\{[log(ratio) - b]/m\}[19] \qquad (7)$$

The above equation serves to obtain the ppm value of ammonia in the air, where the calculation is initialized into the program so that the MQ-135 sensor reading value in the tobacco oven is obtained. The test was carried out under two conditions, namely the first condition by providing a source of smoke from burning tobacco leaves wrapped in paper and the second condition by placing the MQ-135 smoke sensor in a working oven.

TABLE II. THE TEST RESULTS OF THE MQ-135 SENSOR TOWARDS THE SMOKE OF BURNED TOBACCO LEAVES

No	Time	PPM ammonia
1	15:30	0.46 ppm
2	15:31	3.73 ppm
3	15:32	4.22 ppm
4	15:33	4.42 ppm
5	15:34	4.35 ppm
6	15:35	3.77 ppm

The first test was carried out to test the ability of the MQ-135 sensor to read the value of the change in PPM smoke when the sensor was given smoke for 5 minutes. Based on the data obtained, the MQ-135 sensor can take readings of changes in PPM in the air when brought close to the smoke source.

Fig. 17. MQ-135 sensor test with smoke

TABLE III. THE TEST RESULTS OF THE MQ-135 SENSOR ON THE TOBACCO OVEN ARE ON

No	Time	PPM ammonia
1	19:24	2.04 ppm
2	20:00	1.43 ppm
3	21:00	1.84 ppm
4	22:00	1.63 ppm
5	23:00	0.95 ppm
6	24:00	1.47 ppm

In the second test, six samples were taken, each of which was approximately 1 hour apart from each sample. After testing for more than 7 hours, it is known that the state of the ammonia ppm in the working tobacco oven is not more than 3ppm, so in this case, it is determined that when the ammonia ppm exceeds 3ppm, it indicates a danger warning in the tobacco oven.

Fig. 18. The test of the MQ-135 sensor on the tobacco oven that are on.

C.3. DHT22 Temperature Sensor Testing

The first test of the DHT22 temperature sensor was carried out to determine the changes and the level of accuracy of the DHT22 sensor to the thermometer in the tobacco oven. The measurement of accuracy of the DHT22 sensor on the thermometer is calculated using the Eq. 8.

$$Error = \frac{Value\ difference}{Value\ of\ Thermometer}\, x\ 100\ \% \qquad (8)$$

The following are the test results of the DHT22 sensor.

TABLE III. DHT22 SENSOR TEST RESULTS IN TOBACCO OVEN

No	DHT22 in ºCelcius	Termometer in ºCelcius	Difference	Error %
1	57.20	58.00	1.20	2.06
2	61.10	62.00	0.90	1.45
3	58.30	59.00	0.30	0.5
4	63.50	65.50	2.00	3.05
5	63.70	64.30	0.60	0.93
6	59.00	59.30	0.30	0.5
7	60.10	61.30	1.20	1.95
8	57.40	58.30	0.90	1.54
9	57.00	58.00	1.00	1.72
Average				1.5

From the above test, 9 samples were taken, each of which came from the value of the DHT22 sensor and thermometer. The data obtained shows the resulting error value is 1.5%, so it can be concluded that the DHT22 temperature sensor works quite well in detecting the temperature of the tobacco oven. The placement of DHT22 temperature sensor is placed parallel and adjacent to the thermometer but attached to the wall of the tobacco oven so that it gets similar readings from the thermometer which has often used to monitor the temperature of the tobacco oven.

Fig. 19. The look of thermometer on tobacco oven

The second test of the DHT22 temperature sensor was carried out to determine the system's reaction when the DHT22 sensor detected a temperature of more than 80o Celsius which is not an ideal temperature for a tobacco oven. In this second test, a food oven was used as a test medium with a maximum temperature of 100° Celsius, and the DHT22 temperature sensor was placed in the oven for 30 minutes. This test was carried out because the conditions did not allow to raise the temperature in the tobacco oven more than 80° Celsius.

TABLE V. DHT22 sensor test results on food oven

No	Minute	DHT22 in °Celcius	Telegram Notification
1	First	43.10	Not received
2	Second	60.40	Not received
3	Third	79.70	Not received
4	Fourth	87.10	Received
5	Fifth	98.70	Received
6	Sixth	99.10	Received
7	Seventh	98.90	Received
8	Eighth	99.30	Received

From testing result the DHT22 sensor on the food oven in Table V, eight samples were taken from the first 10 minutes of testing, the reaction of the system on the food oven showed that the system was able to send a warning notification when the temperature exceeded 80° Celsius, the warning notification kept coming in continuously when the system reads that the temperature is still worth more than 80° Celsius.

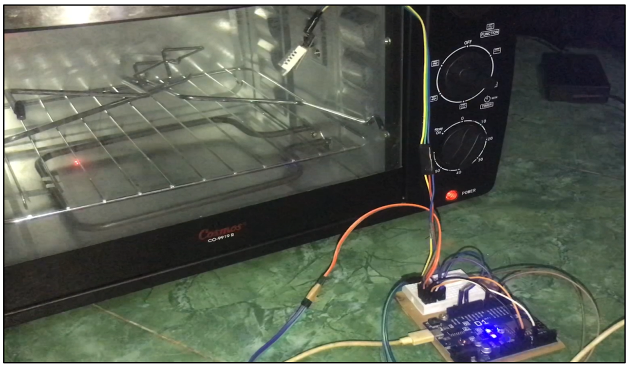

Fig. 20. DHT22 sensor test on food oven

C.4. Buzzer Test

The testing of the buzzer is to determine whether the buzzer can provide sound notification when there is an indication of fire in the tobacco oven. The results of the buzzer test shown in Table VI.

TABLE VI. BUZZER TEST

No	Scenario	Buzzer status		Time required
		On	Off	
1	Giving a fire source to the infrared flame sensor with a large intensity so that the fire is detected in the system	✓		2 Second
2	Giving a source of smoke from burning tobacco leaves to the MQ-135 sensor so that ppm > 3 is detected	✓		2 Second
3	Placing the DHT22 sensor at a temperature condition > 80° Celsius by simulating it in a food oven	✓		2 Second

From the above test, the buzzer is able to sound when the sensors indicate a fire. The buzzer takes up to 2 seconds to sound when the system detects a fire indication by the infrared flame sensor and MQ-135 sensor and when the temperature exceeds 80° Celsius.

V. CONCLUSIONS AND SUGGESTIONS

A. Conclusions

Based on the research that has been done, the conclusions obtained from this research include the following:

1. The early fire detection system in tobacco ovens can work with infrared flame sensors and MQ-135 smoke sensors as an indication of fire in tobacco ovens where the flame sensor that detects the presence of fire or the MQ-135 smoke sensor shows a ppm value > 3 and by sending a message as notification of danger signs on tobacco ovens.
2. The placement of the infrared fire sensor is attached to the wall of the tobacco oven with a downward 30cm from the lowest tobacco rack, with an estimate that the lowest tobacco leaf is the most prone to burning.
3. The early detection system of fires in tobacco oven can monitor temperature, ppm smoke, and fire conditions in tobacco ovens on the Telegram application by sending messages with the command "/Oven" to monitor the overall condition of the tobacco oven, "/Suhu" to monitor temperature, "/Asap" for monitoring ppm conditions and "/Fire" for monitoring fire conditions.

B. Suggestion

If further research is carried out, the following suggestions can be considered:

1. This system can be developed by using more than one smoke sensor and placed on each side of the tobacco

oven so that the readings obtained are more accurate.
2. The system can be developed into a system that can regulate the temperature of the tobacco oven by opening or closing the oven vent using a motor as a driving device.
3. In its application the system has not been able to detect the presence of fire at certain angles with a one-channel infrared flame sensor so suggestions for further research should use an infrared flame sensor with more than one channel such as a five-channel infrared flame sensor to be better able to detect the presence of fire in the whole corner of the tobacco oven.
4. Using a jumper cable that is longer and stronger so that the placement of the sensor in the tobacco oven can be more flexible.

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