

Prototype of Fire, Gas, and Steam Pressure Detection Based on Internet of Things (Case Study: PT Agro Sinergi Nusantara)

Inzar Salfikar^{a,1}, Rizki Faulianur^{a,2*}, Yhona Syela Inri^{a,3}, Dodi Syahputra^{a,4}

^a Program Study Of Mechatronics Engineering, Politeknik Aceh, Politeknik Aceh Street, Banda Aceh City 23116, Indonesia

¹ inzar@politeknikaceh.ac.id; ² rizki@politeknikaceh.ac.id*; ³ yhona271005@gmail.com,

⁴ dodisyahputra1014@gmail.com

* corresponding author

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ABSTRACT

This study is based on a conversation that took place during an industrial visit by Aceh Polytechnic D3 Mechatronics students at PT Agro Sinergi Nusantara (ASN), where the company does not yet have a system in place to monitor gas, steam, and fire pressure in order to reduce hazardous circumstances in the factory. A fire detection system is needed to prevent fires because palm oil factories often have processes that involve flammable materials and have the potential to cause fires. The steam pressure in the boiler of the Steam Power Plant (PLTU) system at PT ASN needs to be monitored to prevent explosions. The PLTU combustion system that utilizes palm oil pulp and empty bunches produces carbon emissions that are harmful to health. Information on carbon gas levels also needs to be known to ensure whether the surrounding conditions are dangerous. The presence of fire, gas and steam pressure needs to be monitored via a smartphone connected to the Internet network. Thus, workers do not have to be close to the machine area because monitoring is sufficient on a smartphone. The research method is a case study at PT ASN, surveys and interviews, literature studies, experiments and simulations on prototypes and data collection in the laboratory. The data used for measurement are fire and gas from matches and air pressure from the compressor. The results obtained, this prototype is able to detect fire, gas and vapor pressure. When fire is detected, pressure and gas that exceed the setting limit will trigger the alarm to activate. The presence of fire and gas and vapor pressure data can be monitored on a smartphone with a delay of 17 seconds. The average accuracy of pressure detection with arduino is 96.20% and smartphone 97.07%.

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I. Introduction

PT Agro Sinergi Nusantara (ASN) is one of the companies in Indonesia that produces crude palm oil through sustainably managed plantations. Established since 2011, PT ASN has now grown into one of the largest palm oil companies in Aceh that manages 16,150 hectares of palm oil plantations, and is supported by ± 1,231 employees who have joined and grown with the company [1]. PT ASN is located in the field area of Johan Pahlawan sub-district, West Aceh district. Some time ago, students and lecturers of the D3 Mechatronics Study Program at the Aceh Polytechnic conducted an Industrial visit to PT ASN [2]. The results of the team's observations, PT ASN has a PLTU power plant that utilizes Empty Palm Oil Bunches and palm dregs for the power plant system in the Palm Oil Mill. The combustion system in the PLTU Boiler produces steam pressure to generate electrical energy by utilizing the kinetic energy of steam that can drive the turbine blades [3]. Furthermore, the turbine works to drive the generator [3]. This steam power is also used for boiling palm fruit.

In the Empty Palm Oil Bunches and palm pulp combustion system, there is a high-pressure process in the boiler. Boiler pressure needs to be monitored to prevent explosions that cause work accidents to employees [4]. The combustion process also produces high carbon emissions.



Currently, the government has conducted co-firing in the power generation system by substituting coal with biomass in the Steam Power Plant [5]. This effort can reduce emissions. However, carbon gas levels still remain so that monitoring is needed. On this basis, this research was conducted to answer the needs in the palm oil industry, especially PT ASN. Therefore, this research aims to create a prototype of a fire, gas and steam pressure detector that can be monitored via smartphone as an early detection of dangerous conditions in palm oil mills. As the first product, this prototype will function as a basic model for further development adjusted to the specific conditions of palm oil mills, especially PT ASN.

In recent years, related research has been conducted on the analysis of the application of fire protection systems at PTPN IV, PKS Pabatu unit, Serdang Begadai [6]. In this study, it was found that there was no detector system in the factory area, either a fire or smoke detector as an early detection of fire that was connected to an alarm. Subsequent research on fire detection systems in palm oil mills has been conducted at PT. Palmanco Inti Sawit [7]. In this study, the fire detection device still uses a buzzer as a warning. IOT has been widely applied to monitoring systems such as forest fires [8]. From several previous research studies, no research has been conducted that utilizes the Internet of Things (IoT) to detect the presence of gas flames and vapor pressure that can potentially cause fires. Therefore, this prototype was created as one of the innovations from previous studies. This study uses a flame sensor to detect fire. A flame sensor is a fire detection sensor through the presence of fire that appears suddenly [9]. The detected flame has a wavelength between 760 nm and 1100 nm [9]. The flame sensor has the advantage of being an intelligent sensor that is able to detect flames with high accuracy even though the flame is as small as a candlelight [10]. To detect gas, the sensor used is the MQ-7 sensor. The MQ-7 sensor is a gas sensor used to detect carbon monoxide in everyday life [11]. This sensor has high sensitivity to carbon monoxide [11]. While the vapor pressure sensor uses a pressure sensor with a capacity of 3Mpa which can detect a maximum pressure of 30 bar/435 Psi.

II. Method

A. Research Flowchart

This research was conducted using an experimental method as shown in the flowchart in Figure 1 below, including a case study at PT ASN through industrial visits, observations and interviews, problem identification and determining problem boundaries, collecting supporting research data, designing tools, both hardware and software. Prototype making and data validation, then testing the tool in the laboratory to test the reliability of the prototype. Furthermore, data analysis and drawing conclusions. In laboratory testing, testing of the MQ-7 sensor and flame sensor used fire and gas produced from matches as test sources. Meanwhile, for testing vapor pressure, air pressure from the compressor was used as a pressure source.

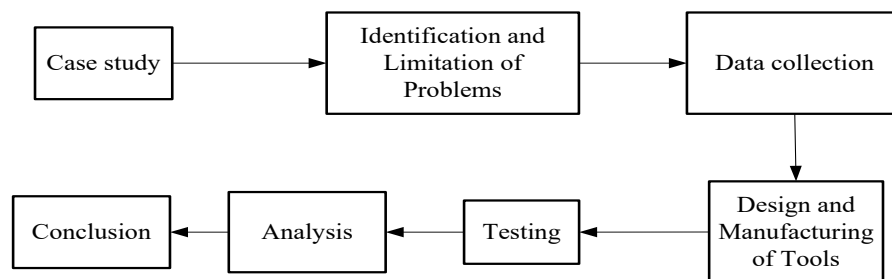


Fig. 1. Research Flow Diagram

How the system works is explained in the flow diagram shown in Figure 2. First the system initialization process, continued with the initialization of fire, steam and gas sensors. If gas and steam are detected around the prototype, the data will be sent to the smartphone via the internet network. And when fire is detected, an alarm will sound and the flame is also detected on the smartphone. When the gas and pressure conditions exceed the set limits, the alarm will sound. After that the alarm can be turned off by the operator and the system is complete.

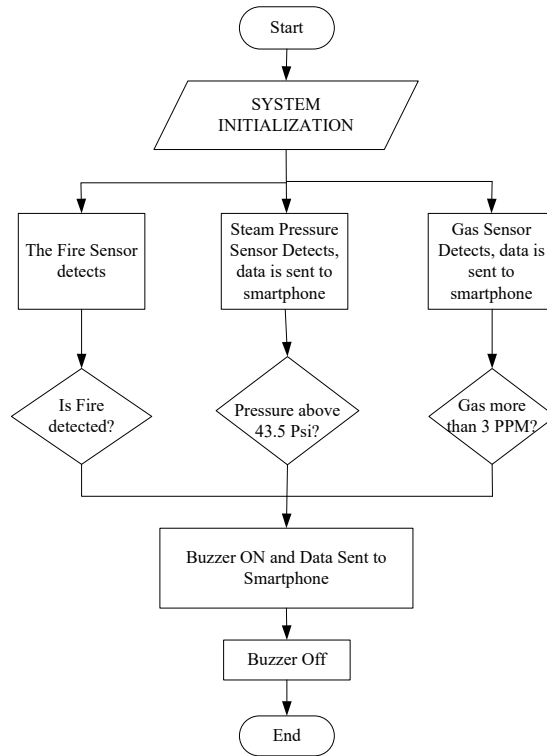


Fig. 2. Flowchart for designing a work system.

B. Block Diagram System

The block diagram system of this research is presented in Figure 3.

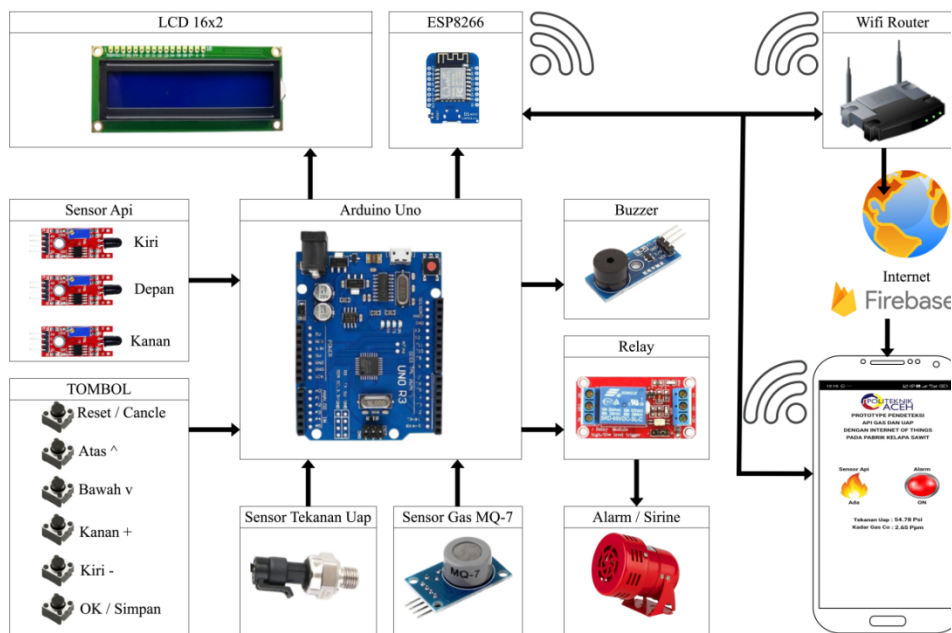


Fig. 3. Block diagram system

From the block diagram it can be seen that the working principle of this tool with a source of 5 volt power supply as input and output arduino. Fire sensor, steam pressure sensor and MQ-7 gas sensor, buttons become arduino input. While those connected to the arduino output are alarms, Liquid Crystal Display (LCD) and smartphones connected via a wifi module.

III. Results and Discussion

This research has succeeded in building a prototype of a fire, gas and steam pressure detector as shown in Figure 4. This prototype has installed 3 flame sensors, MQ-7 sensor and steam pressure sensor located on the left, right and front of prototype. This prototype is also equipped with a button to set the pressure and gas limits. In this section, testing will be carried out, including testing the MQ-7 sensor.

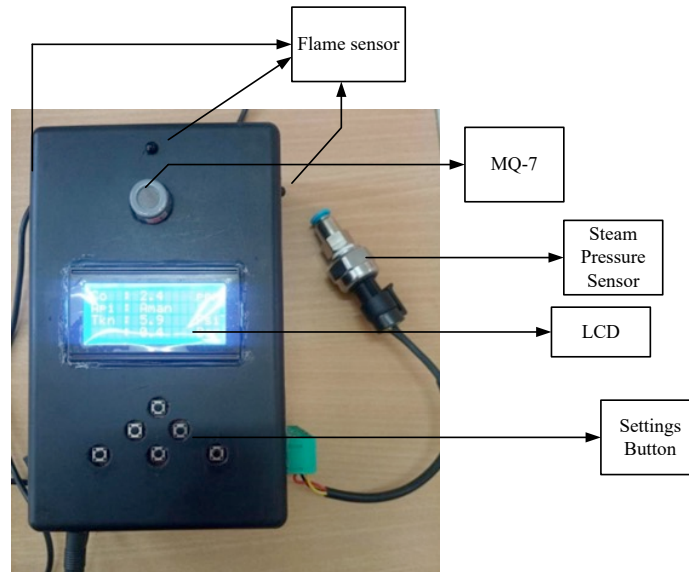


Fig. 4. Results of the gas flame and steam pressure detector prototype research

A. MQ-7 Gas Sensor Testing

This test aims to determine whether the sensor data has been read by Arduino. Sensor data will be displayed on the LCD and Smartphone. The tools and materials needed for testing include the MQ-7 sensor, LCD, Arduino, 5 Volt DC power supply, laptop, sufficient jumper cables and a lighter. The gas being tested is gas sourced from a lighter. The MQ-7 sensor test is carried out by creating an LCD test program on the software, connecting all devices with jumper cables, connecting the device with a DC power supply to the arduino, transferring the program on the software to the arduino, testing by turning on the gas lighter, and finally observing the test results. The Arduino program for testing the MQ-7 gas sensor is shown in figure 5. The MQ7 sensor test results are shown in figure 6.

```

64 void loop() {
65   // // put your main code here, to run repeatedly:
66   carbon = mq7.getPPM();
67   lcd.setCursor(0, 0);
68   lcd.print("Karbon Monoksida");
69   lcd.setCursor([4, 1]);
70   lcd.print(carbon);
71   lcd.print(" ppm ");
72   lcd.setCursor(16, 0);
73   lcd.print("Status : ");
74   if (carbon < 25) {
75     lcd.print("Baik ");
76   } else {
77     lcd.print("Buruk");
78     bunyi(3,500);
79   }
80   lcd.createChar(0, seru);
81   lcd.setCursor(16, 1);
82   lcd.write(byte(0));
83   lcd.print(" 25 ppm > Buruk");
84   delay(1000);
85 }

```

Fig. 5. MQ7 gas sensor test program



Fig. 6. MQ7 sensor reading results at gas levels of 4.16 Ppm

From the test results, it can be seen that Arduino has successfully read the gas from the lighter. However, the gas released from the lighter is still at a safe level for humans to inhale, which is around 4 to 5 ppm. The reading data from the gas sensor is displayed on the LCD and smartphone. Comparison data of the sensor reading results on the LCD and smartphone are shown in table 1.

Table 1. Comparison of gas sensor data on LCD and Smartphone

No	Test	Smartphone Display	LCD Display
1	Test 1		



From the test results it is known that the MQ 7 sensor data has been successfully read on the smartphone correctly and accurately. From the data in the table shows the gas levels displayed on the smartphone are in accordance with the gas data displayed on the LCD. In the first test with a percentage error of 0% and the second test with a percentage error of 4%.

B. Flame Sensor Testing

This test aims to determine whether the fire sensor successfully detects fire around the prototype, in addition to whether the presence of fire can be displayed on the LCD and smartphone. The tools and materials needed for this test include a prototype that has been installed with a fire sensor, LCD, Smartphone and lighter. In the fire sensor test, the steps include turning on the prototype, lighting a lighter around the prototype, opening the application on the smartphone and observing the test results. The results of the fire sensor test displayed on the LCD and on the smartphone are shown in figure 7 and figure 8.



Fig. 7. Flame sensor test results



Fig. 8. Display of the detected Fire sensor on the smartphone

The test results show that when the flame sensor detects the presence of fire, the LCD displays the words 'Bahaya'. In addition, the IoT system indicates the presence of fire and in response to the detection of fire, the alarm sounds.

C. Steam Pressure Sensor Testing

This test aims to determine whether the vapor pressure can be detected accurately by the prototype and smartphone device. The tools and materials needed for this test include a prototype that has a vapor pressure sensor installed, LCD, smartphone, compressor, hose and regulator. The vapor pressure sensor test is carried out through several stages including connecting the hose to the vapor pressure sensor, turning on the prototype and waiting a few moments for the system to load. After that the compressor is turned on and the pressure is regulated using the regulator. Furthermore, the application on the smartphone is opened to observe the test results and pay attention to the display on the LCD. The first test was carried out at a pressure of 1.5 Bar or 21.75 Psi. The results of the pressure sensor test displayed on the LCD and smartphone device are shown in Figure 9.

The figure shows the results of the vapor pressure test at a pressure of 1.5 Bar or 21.75 Psi with close results, namely 21.1 Psi on the Arduino and 22.21 Psi on the smartphone. Based on these results, it is known that the reading error rate on the Arduino is 2.98% while on the smartphone it is 2.11%. Furthermore, testing was carried out at a pressure of 2 Bar or 29 Psi. The test results are shown in Figure 10. Based on the test results, the pressure read on the Arduino is 30.6 Psi while on the smartphone it is 30.7 Psi. Based on these results, it can be seen that the error rate on the Arduino is 5.55% and on the smartphone 5.58%. The results of the calculation of the error rate and accuracy are presented in Table 1. Based on the data in Table 1 which contains the results of four tests, the average percentage of accuracy of the vapor pressure measurement compared to the actual data is obtained. The results obtained on the Arduino showed an accuracy level of 96.20%, while with the smartphone it showed a slightly higher accuracy of 97.07%. The percentage of error was calculated using "(1)" while the percentage of accuracy used "(2)".

$$\text{Error Percentage} = \left| \frac{\text{actual pressure} - \text{pressure measurement}}{\text{actual pressure}} \right| \times 100 \% \quad (1)$$

$$\text{percentage of accuracy} = 1 - \text{Error Percentage} \quad (2)$$



Fig. 9. Display of vapor pressure on LCD and smartphone



Fig. 10. Pressure test at 29 Psi

Table 2. Results of vapor pressure measurements

NO	Regulator Pressure (Psi)	Arduino read pressure (Psi)	Pressure On Smartphone (Psi)	Error percentage (%)		Percentage of accuracy (%)	
				Arduino	Smartphone	Arduino	Smartphone
1	21,75	21,1	22,21	2,98	2,11	97,02	97,89
2	29	30,6	30,7	5,55	5,58	94,45	94,42
3	43,5	46,4	45,23	6,66	3,97	93,34	96,03
4	63,8	63,8	63,76	0	0,06	100	99,94

D. Alarm Test

This test aims to determine whether the alarm functions properly when the flame sensor detects the presence of fire, and to ensure that the alarm is active when gas and steam exceed the set limits. In addition, testing is also carried out to verify whether the alarm condition can be detected on a

smartphone device. The tools and materials needed for testing include a prototype that has been installed with a flame sensor, MQ-7 and steam pressure, LCD, smartphone, compressor, hose and regulator. The testing steps begin by turning on the prototype, then testing is carried out one by one for the flame sensor, MQ-7 sensor, and steam pressure. Observe the test results on the LCD and smartphone for each test. The alarm test results are shown in table 2 and figures 11, 12 and 13.

Table 3. Alarm testing

No	Sensor Name	Result	Details
1	Sensor Flame	Alarm <i>on</i>	Alarm <i>on</i> when fire is detected
2	Sensor MQ-7	Alarm <i>on</i>	Alarm <i>on</i> when gas levels exceed 3 ppm
3	Steam pressure sensor	Alarm <i>on</i>	Alarm <i>on</i> when the pressure exceeds 3 Bar or 43.5 Psi

Figure 11 shows a screenshot of a smartphone when the flame sensor detects fire. When fire is detected, the alarm immediately goes off and the information is displayed on the smartphone screen. For vapor pressure testing, the alarm will only be activated when the pressure exceeds the specified limit, which is 3 bar or 43.5 Psi as shown in Figure 12. In the figure, when the vapor pressure sensor detects excess pressure, the data on the Arduino is immediately read within 2 seconds, but the data on the smartphone is delayed for 17 seconds. This delay is caused by the IoT system which is affected by the internet network connection. A similar condition also occurs in gas level testing. When the gas sensor detects gas levels exceeding 3 ppm, the alarm immediately goes off, but the data displayed on the smartphone is also delayed by 17 seconds. After the delay, the gas level and alarm information are only displayed on the smartphone.



Fig. 11. Smartphone screenshot for alarm testing when fire is detected

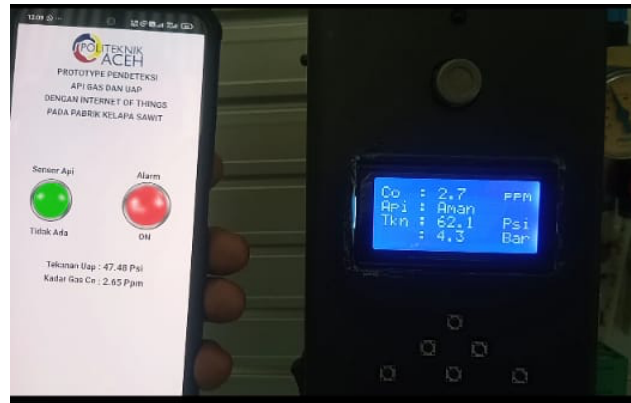


Fig. 12. Alarm testing with pressure exceeding 43.5 Psi



Fig. 13. Alarm testing with gas levels exceeding 3 PPM.

IV. Conclusion

Based on the results obtained, the following conclusions can be drawn:

1. The test results show that when the flame sensor detects the presence of fire, the alarm is automatically activated and information about the presence of fire is read on the smartphone device.
2. The gas sensor that detects gas levels exceeding 3 ppm will activate the alarm and information about the activation of the alarm is displayed on the smartphone screen.
3. Measuring vapor pressure with Arduino has an accuracy level of 96.20% while with a smartphone shows a slightly higher accuracy of 97.07%.
4. The data displayed on the LCD is read faster than the data that appears on the smartphone which experiences a delay of 17 seconds. Despite the delay, the data displayed on both devices is close to the same, indicating consistency of the results despite the difference in display time.

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