RANCANG BANGUN SISTEM *MONITORING* SUHU *CONTINUOUS SETTLING TANK* (CST) DAN LEVEL KOLAM LIMBAH DI PABRIK KELAPA SAWIT

TUGAS AKHIR

Diajukan Sebagai Salah Satu Syarat untuk Memperoleh Gelar Sarjana Teknik pada
Program Studi Teknik Elektro Fakultas Sains dan Teknologi

Oleh:

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UNIVERSITAS ISLAM NEGERI SULTAN SYARIF KASIM RIAU
PEKANBARU
2023

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Design and Implementation of Continuous Settling Tank (CST) Temperature Monitoring System and Waste Pond Level in a Palm Oil Mills

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Abstract — Improving time efficiency and reducing work risks are crucial in palm oil mill operations. Two vital factors in palm oil mill operations are CST temperature and effluent pond level. Both of these factors have a significant impact on mill efficiency. Extreme temperatures, either too high or too low, can disrupt the settling and separation process of water, oil and sludge. In addition, overflowing effluent pond levels are often missed by technicians, so checking must be done manually. This research aims to develop a monitoring system that can monitor the temperature of the CST in safe conditions and measure the level of the waste pond in real time by utilizing Internet of Things (IoT) technology. This control system relies on components such as the NodeMCU ESP8266 microcontroller, DS18B20 temperature sensor, and HC-SR04 proximity sensor. The method used is the design and manufacture of a prototype monitoring system. Field test results show that this system can make comparisons with manual measurement methods. In testing the CST temperature sensor and the waste pond level sensor, the accuracy rate reached 100%. The temperature was successfully monitored with a safe limit of 89°C, while the waste pond level was monitored through the monitoring website. This Internet of Things-based monitoring system has shown significant potential in improving the efficiency and safety of palm oil mill operations and enables mill operators to conduct remote real-time monitoring effectively.

Keywords — Continuous Settling Tank (CST) and effluent pond level, monitoring, real-time, Internet of Things, NodeMCU ESP8266

I. INTRODUCTION

In palm oil mill operations, the temperature in the Continuous Settling Tank (CST) and waste pond levels play a vital role. Accuracy in maintaining the CST temperature between 80 ºC to 90 ºC is very important, considering that the products from CST are grouped into three fractions: oil, sludge and water. Optimal temperature ensures Crude quality Palm Oil (CPO). Temperatures exceeding 90 ºC can disrupt the sludge deposition process due to the evaporation of water particles at the bottom of the tank, which ultimately causes sludge to be mixed again with oil. Meanwhile, temperatures of less than 80 ºC can slow down the deposition process [1]. Correspondingly, maintaining waste pond levels is also a critical aspect of operations. Excessive waste volume has the potential to cause overflows, which can threaten environmental quality, especially regarding water quality [2].

To increase the efficiency and accuracy of supervision, adopting Internet-based technology of Things (IoT) is becoming a strategic consideration. Conventional methods that involve employees monitoring conditions directly create the potential for errors and safety risks. In contrast, IoT-based automated systems offer higher accuracy, efficiency and safety. The implementation of this technology has an impact not only on improving operational quality but also on fulfilling environmental regulations, mitigating the risk of equipment failure, and achieving customer satisfaction. Therefore, investment in automation technology such as IoT is a necessity for palm oil mills to ensure sustainable, efficient and environmentally responsible operations.

One effort to overcome the challenges of temperature monitoring is research that builds a temperature monitoring and control system for Hard Chrome tanks. This system is designed to monitor and control temperatures in the range of 45°C to 65°C. In this research, the ESP8266 microcontroller was applied to process and transmit data from sensors to the PT_BENS application via the Internet of Things(IoT). This way, workers can monitor and control the temperature in the Hard Chrome tank efficiently and accurately. The results of this research not only contribute to the development of industrial monitoring technology but also open up opportunities to increase efficiency in contemporary industrial practice [3]. Furthermore, this research provides a new perspective regarding the importance of monitoring CST temperatures in palm oil mills. Both monitoring systems in Hard Chrome tanks and CST in palm oil mills both emphasize the importance of monitoring technology to maintain optimal conditions. This kind of technology has the potential to be adopted in various industries to improve the efficiency and quality of production processes.

In an effort to facilitate mechanical activities in monitoring fuel tank filling temperatures, this research developed a monitoring system that utilizes an Omron CP1E type PLC together with a thermal sensor. The aim is to monitor the stability of the temperature in the fuel tank with an average error rate of 6.2% [4]. In addition, a separate study related to controlling the temperature of a water heating tank using an Arduino UNO and a PT100 RTD temperature sensor. This system is designed to monitor the temperature stability of the water heating tank and will be applied as a test medium in evaluating PID controllers. This control aims to regulate the water temperature according to the set point and manage the height and volume of water in the tank with the help of a voltage divider [5]. The application of temperature and tank volume monitoring technology, as outlined in both studies, offers a positive impact in optimizing palm oil mill operations. Utilization of the Internet of Things (IoT) concept in monitoring CST temperature shows a reduction in the potential for production failures, increased time efficiency, and mitigated work risks. The results of these two studies show promising potential for the adoption of similar technologies in industrial process monitoring, ultimately contributing to increased productivity and quality.

The research carried out aims to overcome the issue of water availability in rice fields by developing an SMS gateway-based water level monitoring system. This system is designed to ensure that rice fields remain available and do not experience drought or overflow. The main components used in this research include Arduino Uno as a microcontroller, SIM800l V2 for sending and receiving signals, and HC-SR04 as a distance detection sensor [6]. However, there are weaknesses in the method of sending information via SMS, where it is less practical and requires relatively larger costs for each sending. As an alternative, research currently being developed focuses more on the use of data packages via the Internet, which is considered more economical, has a wider reach and is easier to access.

The HC-SR04 ultrasonic sensor has been applied in monitoring systems, including flood detection. When water approaches the sensor, NodeMCU will send data to the MySQL database in real time, activate the siren, and indicate alert status via a web display [7]. As another example, the design of a rainwater harvesting pond control system utilizes the Arduino Uno R3 microcontroller, DHT22 sensor, and HC-SR04 ultrasonic sensor. The system sends email notifications to staff to monitor the water level in the holding pond [8]. The application of the HC-SR04 in a water level monitoring system in palm oil mill waste ponds shows how the technology can be adapted for various environments. In the context of the palm oil industry, this technology helps prevent potential environmental impacts due to excess waste. The use of the HC-SR04 in a flood detection system also illustrates how technology can be utilized to address flood risks with rapid response.

The main problem faced was the reliance of factory employees on manual methods in monitoring CST temperatures and waste pond levels in one of the factory's factory, coconut South Kalimantan palm oil, which is important for assessing safety conditions. This manual approach has limitations, including the inability to monitor over a 24-hour period and the potential for measurement and recording errors. To overcome this problem, this research proposes an automatic system to monitor CST temperature and waste pond level. Data collected by the system will be stored in the website database and can be accessed in real-time. It is hoped that through this innovation, the efficiency of factory employees' working time can be increased while reducing the potential risk of accidents.

II. RESEARCH METHODS

This research was conducted at one of the palm oil factories located in South Kalimantan. With CST specifications, it is a circular tank with a diameter of 4 m, a height of 9.5 m, and a volume of 120 ^{m3}. For specifications, the waste pond is rectangular, with a length of 58 m and a depth of 4 m. In this research, an equipment design method involving electrical and mechanical aspects is used. There are 3 stages of this research, namely hardware design, website (monitoring interface), and software design.

A. Hardware design

Hardware design for monitoring CST temperature and waste pond levels in palm oil mills involves several important components. The data obtained will be sent via the communication network to a centralized monitoring system. In hardware design, it is important to understand the working principles of the tools used. Information about how this tool works will be illustrated in Figure 1 below.

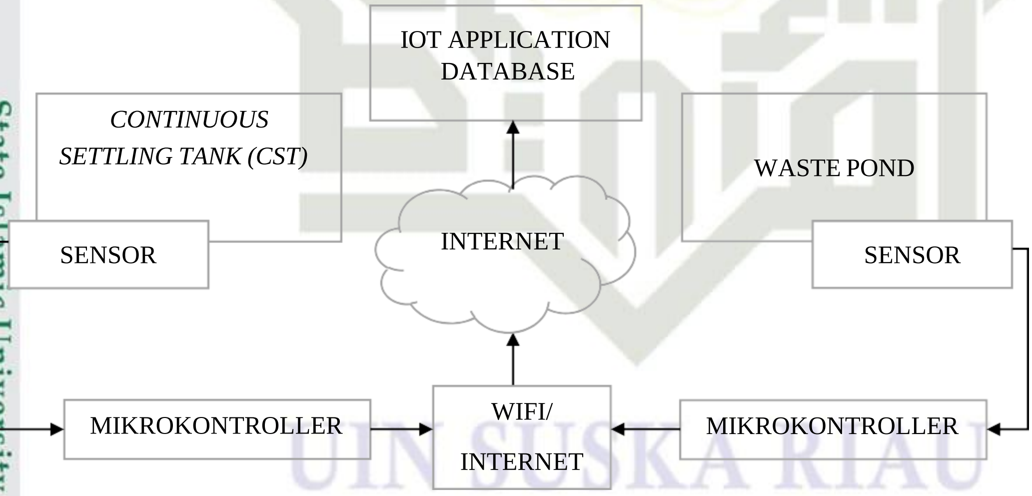
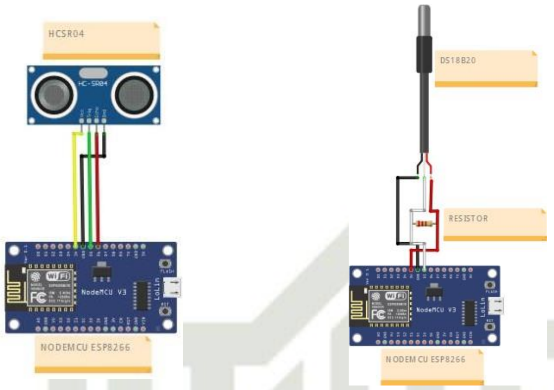


Figure 1. Flow diagram of the CST temperature monitoring system and waste pond level

The working principle of the system in Figure 1 can be explained in several steps. First, the sensor takes data related to the parameters you want to measure, such as temperature and water level. Analog data from the sensor is then converted into digital format so that it can be processed by the microcontroller. The microcontroller receives this digital data and performs additional processing, such as average calculation or threshold checking. Next, the microcontroller connects to a Wi-Fi network or Internet. The processed data is sent by the microcontroller via a Wi-Fi / Internet connection to the destination cloud. In cloud services, data is received, validated and stored in a web database. The web is an interface that functions to monitor data stored in a database. Data is displayed in the form of graphs and numbers so that it can be understood easily. Users can monitor data in real-time or view previous data history. Based on the monitored data, users can perform analysis, make decisions, or take necessary actions via the web. Thus, this system allows efficient monitoring and control of sensor data and is connected to a Wi-Fi / Internet network.



(a) (b)

Figure 2. Wiring diagram measurement of CST temperature and waste pond level

Figure 2 (a) is the wiring from the distance detection device, and 2 (b) is the temperature measurement wiring; this wiring is made using the software Fritzing. The following is an explanation of the function of each hardware component in Figure 2, which is shown in Table 1.

Table 1. Hardware Components

Component	Function
NODEMCU ESP8266	controller (microcontroller)
HC-SR04	detect object distance
DS18B20	measure the temperature of the unit
Resistors	regulate the flow of electric current

This implementation uses 2 sensors, namely the HC-SR04 sensor (Ultrasonic Sensor) and the DS18B20 sensor (Temperature Sensor); here is the explanation:

1. HCSR-04

The HC-SR04 sensor is an ultrasonic sensor that converts physical quantities (sound) into distance quantities. The nature of ultrasonic waves can only propagate in liquids, solids and gases [8]. On the HC-SR04, there is a pair of ultrasonic transducers, one of which functions as a transmitter of ultrasonic sound wave signals with a frequency of 40KHz and the other as a receiver of ultrasonic wave signals [9]with a measurement potential of 300 cm [10]. The HC-SR04 image can be seen in Figure 3.

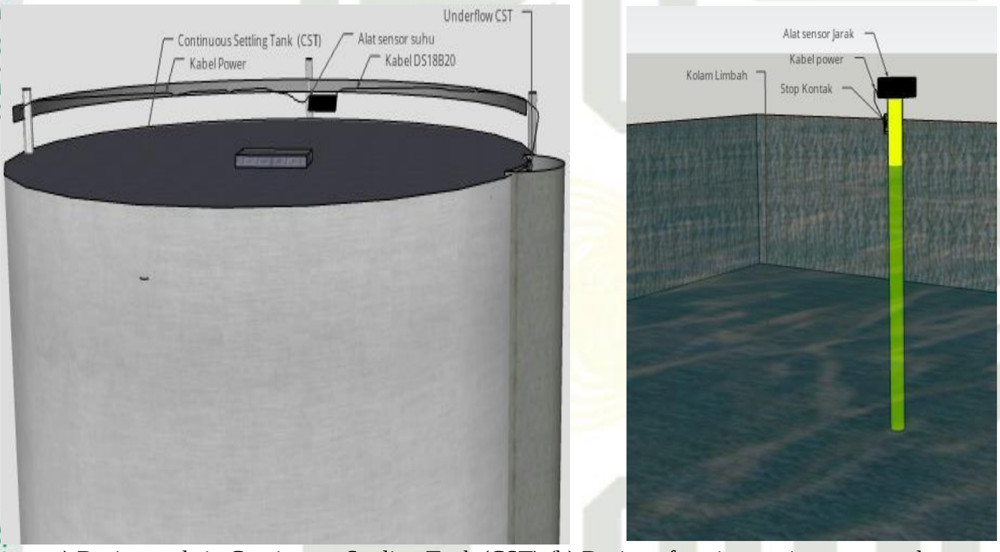
Figure 3. HC-SR04 (Ultrasonic Sensor)

2. DS18B20

The DS18B20 temperature sensor is a sensor that is waterproof and capable of measuring temperature in wet conditions [11], according to the datasheet. This sensor is capable of measuring temperatures up to 125˚C, but it is recommended to measure temperatures below 100˚C [12].

Figure 4. DS18B20 (Temperature Sensor)

Overall, the design of the temperature monitoring device is Continuous. The Settling Tank (CST) and waste pond level consist of several main components, namely the control box, Continuous Settling Tank (CST), and waste pond. Shape tool design in Continuous The Settling Tank (CST) can be seen in Figure 5 (a), and the design of the equipment in the waste pond can be seen in Figure 5 (b).



a) Design tools in Continuous Settling Tank (CST) (b) Design of equipment in waste ponds

Figure 5. Equipment design in the palm oil mill processing unit

B. Website

A website is a collection of sites on the World Wide Web (WWW) network on the internet. The website is designed as the main interface for connecting and integrating the Internet of Systems Things (IoT), which is complex, giving users the ability to monitor, control, and manage multiple connected devices through one unified platform. The web is usually created via Hyper Text Markup Language (HTML) or Extensible Hyper Text Markup Language (XHTML) [13].

Within the framework of this monitoring system, notification or alarm facilities are realized when the value of a parameter is below or above the setpoint and are not available in the implemented web interface layer. This happens because the web platform used comes from the company entity itself and is not equipped with a notification or alarm mechanism. The causes of the alarm feature on the website monitoring are not yet available because the company is still developing the website.

Table 2 shows the standard parameters for measuring CST temperature and waste pond level. In the measurement, there are 3 indicators, namely safety, warning, and danger. The safe indicator temperature is 86 - 90 °C, warning 30 - 85 °C, and danger 91 -

100 °C. The safe indicator distance is 300 - 349 cm, warning 350 - 375 cm, and danger 376 - 400 cm.

Table 2. Standards CST temperature measurement parameters and waste pond levels [14][15]

No	CST Temperature	Indicator	Waste pond level	Indicator
1	86 - 90 °C	Safe	300 - 349 cm	Safe
2	30 - 85 °C	Warning	350 - 375 cm	Warning
3	91 - 100 °C	Danger	376 - 400 cm	Danger

C. Software design

In this research, the software used is software Arduino and website monitoring. The software design is visualized in the form of a flowchart, which can be seen in Figure 6. When the tool is turned on, the system initialization process is carried out. If connected to the internet, then the sensor reading process is carried out; if not, it will return to the system initialization process. After reading the sensor, the process of sending sensor measurement data is then displayed on the web display.

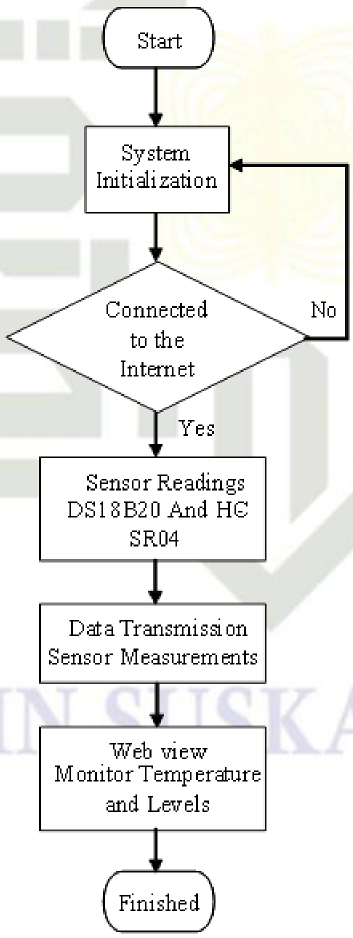


Figure 6. Flowchart of the communication process between the device and the website

Testing was carried out to ensure the accuracy of the sensor by comparing the sensor measurement results with standard measurements and the success of the web display in displaying CST temperature data and waste pond levels. In this research, two things were observed, namely, the temperature in the Continuous Settling Tank (CST) and waste pond levels. The CST temperature is measured periodically to ensure efficient separation, while water level data in the waste pond is monitored to prevent waste overflows that could have a negative impact on the environment.

Experiments measuring CST temperature and waste pond levels were carried out separately and took place over a period of a week. To observe the CST temperature, data is taken and monitored for 9 hours, starting from 09:00 to 17:00. Meanwhile, measurements of the waste pond level were carried out for 20 hours, starting from 16.00 to 12.00 the next day. Data collection, which took place over this duration, aims to collect more complete and representative information about the condition of CST and production process waste ponds.

In an effort to increase efficiency and maintain sustainability in the palm oil industry, a system for monitoring CST temperature and waste pond levels was developed. The process begins with needs analysis and appropriate sensor design. Sensors are installed in the CST underflow and waste ponds. Software is built to manage sensor data, and a web view is available for real-time monitoring. The system enables rapid response to temperature and level changes, increasing operational efficiency and complying with environmental regulations. During the research and development of the CST temperature monitoring system and waste pond levels in palm oil mills, we experienced a number of technical obstacles. One of the main problems was a program error, which resulted in sensor data not being sent to the company website.

III. RESULTS AND DISCUSSION

The designed tool is implemented directly in the palm oil factory to test the telemetry system (in real-time), which is applied to the Continuous Settling Tank (CST) and waste pond levels, shown in Figures 7 and 8.

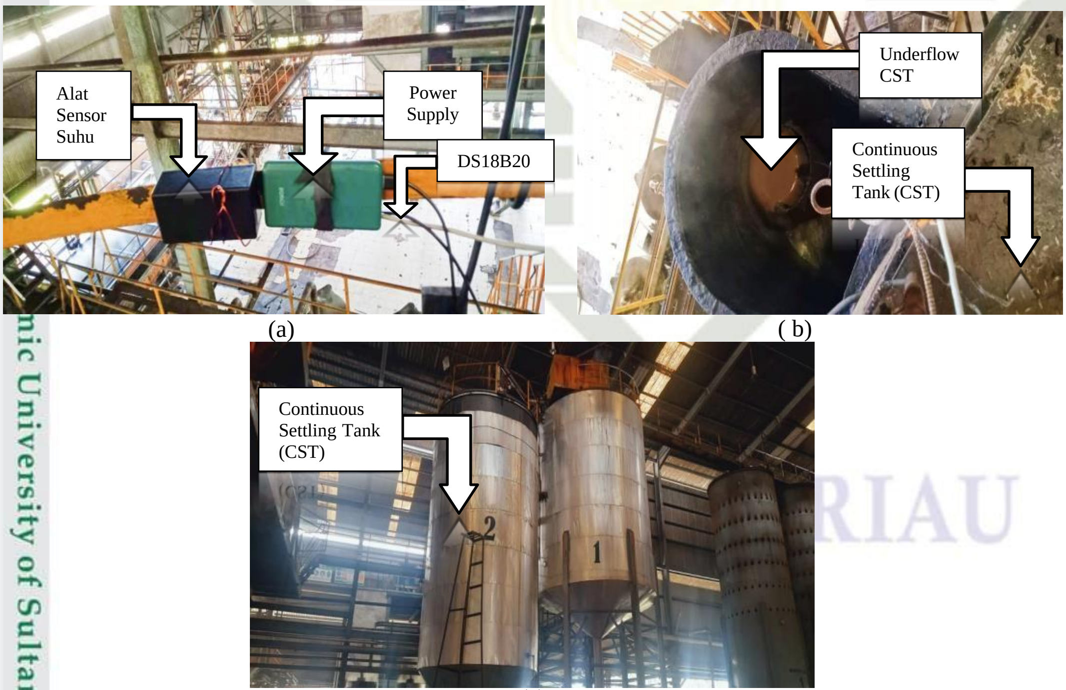
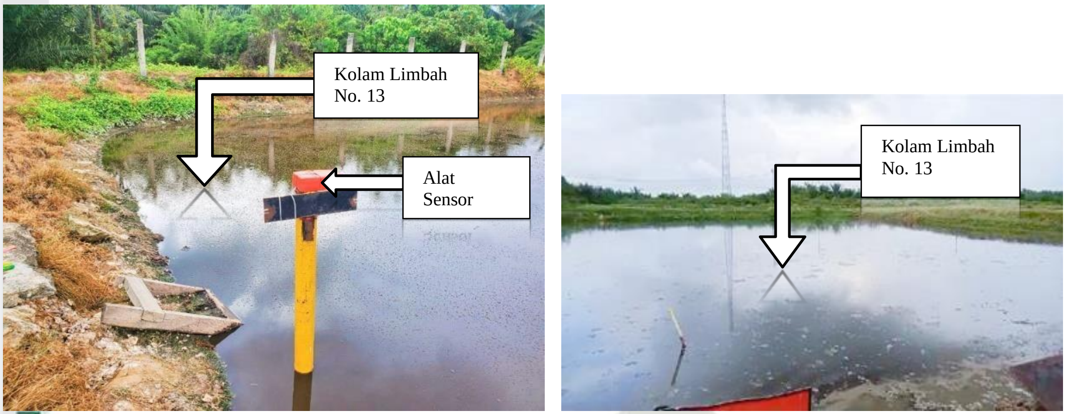


Figure 7. Display of the temperature sensor tool in the Continuous Settling Tank (CST)



(a) (b)

Figure 8. Display of the distance sensor device in the waste pond

From the illustration in Figure 7, a temperature sensor is installed on the Continuous Settling Tank, with a DS18B20 sensor inserted into the CST underflow, which functions to control and manage the continuous separation between liquid and solid phases that occurs during the process of separating palm oil from liquid mixtures involving solids.

From the illustration in Figure 8, a distance sensor device is installed in the 13th waste pond (final waste pond). The final waste pond process in a palm oil mill involves a settling pond or aerobic pond. Liquid waste is left in a pond to separate heavier solids. The top of the pool contains clearer water, while the solids settle at the bottom. Wastewater is usually reused to fertilize palm trees with lower pollution levels while the solids are removed or processed further.

A. Testing the accuracy of temperature and distance sensors

Sensor testing was carried out to determine the accuracy of the DS18B20 and HC-SR04 sensors. Then, the results of this test will be compared with the results of the thermometer measurements existing gauge in the production unit with a reading accuracy of ± 0.5°C and a ruler for measuring distances. The experiment was carried out 5 (five) times. Based on Table 3, it can be seen that the sensor readings show similar values when compared with standard measuring instruments, with accuracy reaching 100% on the DS18B20 and HC-SR04 sensors.

Table 3. Test results for the accuracy of the CST temperature sensor and waste pond level

First try -	CST Temperature			Indicator	Waste pond level			Indicator
	DS18 B20	Thermo gauges	Error		HC-SR04	Ruler	Error	
1	89°C	89°C	0 °C	Safe	340 cm	340 cm	0 cm	Safe
2	89°C	89°C	0 °C	Safe	338 cm	338 cm	0 cm	Safe
3	84°C	84°C	0 °C	Warning	364 cm	364 cm	0 cm	Warning
4	85°C	85°C	0 °C	Warning	361 cm	361 cm	0 cm	Warning
5	93°C	93°C	0 °C	Danger	382 cm	382 cm	0 cm	Danger

Table 3 presents a comparison of sensor measurement results with standard measurements, along with the recorded error values. In the first experiment, the CST temperature was recorded at 89°C on the sensor, which agreed with the measurement on the thermo gauge with an error of 0°C. The same results were found in the second experiment, where the CST temperature reached 89°C and the measurement error remained 0°C. In the third experiment, the CST temperature reached 84°C (warning), while the error value remained 0°C. Similar results were also seen in the fourth experiment, where the CST temperature reached 85°C (warning) and the measurement error was 0°C. In the fifth experiment, the CST temperature reached 93°C (danger), and the measurement error remained at 0°C.

The same applies to waste pond level measurements. In all experiments, a comparison of sensor measurements with standard equipment showed an error of 0 cm for the safety, warning, and danger indicators. Even though in the fifth experimental situation, there was a significant increase in the waste pond level (382cm), a comparison of sensor measurements with standard equipment showed that the error value remained at 0 cm.

B. Testing connectivity between devices and websites.

At this testing stage, the connectivity between the device and the web is used to determine the performance of the device to the web working well. The devices in this test are ESP8266, DS18B20 sensor, HC-SR04 sensor, and software Arduino Uno. In the software Arduino Uno, you can see the value of the data read directly via the serial monitor. And monitoring devices remotely can be done via the web.

Table 4. ESP8266 measurement results on the monitoring website

First try -	Device		Web	Device		Web
	CST Temperature	Indicator		Waste pond level	Indicator	
1	89°C	Safe	√	340 cm	Safe	√
2	89°C	Safe	√	338 cm	Safe	√
3	84°C	Warning	√	364 cm	Warning	√
4	85°C	Warning	√	361 cm	Warning	√
5	93°C	Danger	√	382 cm	Danger	√

Table 4 shows the results of measuring the CST temperature and waste pond level connected to the website via the ESP8266 device. In the first experiment, the CST temperature was 89°C (safe) and corresponded to the display on the web marked with a tick (√). This result also occurred in the second experiment at the same temperature. Likewise, in the third experiment, with a CST temperature of 84 °C (warning), the web displayed according to that in I tick mark (√). In the fourth experiment, with a temperature of 85 °C (warning), the results remained consistent with the web. In the fifth experiment, the CST temperature reached 93 °C (danger) in an appropriate web display marked with a check mark (√).

The same applies to waste pond level measurements. In all experiments, the appearance of the website consistently displays a check mark (√) for safety, warning, and danger indicators. Even though in the fifth experimental situation, there was a significant increase in the waste pond level (382 cm), the web display still showed a check mark (√) on the danger indicator.

From the results of this test, there were 5 (five) attempts to send data to the web. All tests have been successfully carried out as indicated by a check mark (√) in the web column.

C. Field performance testing of CST temperature monitoring systems and waste pond levels at palm oil mills

In field testing, system performance was observed by recording data for approximately 9 hours for CST temperature and 20 hours for waste pond level. The results of the data recording are shown in Figures 9 and 10. The monitoring display of CST temperature and waste pond level via the web can be seen in Figure 11.

From the illustration in Figure 9, temperature analysis in the CST of palm oil mills at certain hours shows variations. From 09:00 to 11:00, the temperature was in the range of 84-85°C (warning) but was still below the safe limit. At 12.00, the safe temperature is 89°C. However, at 13:00-16:00, the temperature slightly increased (91-93°C). Strong suspicions emerged that this phenomenon might be caused by the accumulation of sludge, which hampered the efficiency of heat flow. If there is an increase in temperature at the CST, reactive action is taken by factory employees by reducing the valve opening of the temporary CST heater. Likewise, if the CST temperature decreases, the factory employee will open the valve of the CST heaters. This is done until the temperature on the CST indicator reaches a safe level in accordance with established standards. At 5 o'clock, the temperature returned to a safe 89°C. Despite fluctuations, the temperature is still within the desired limits.

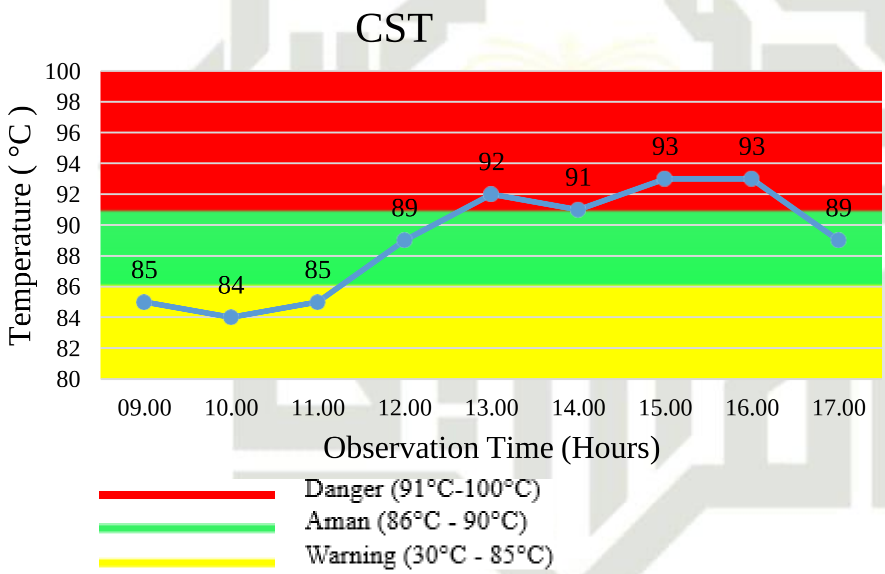


Figure 9. Data recorded on the CST temperature monitoring system

From the illustration in Figure 10, in the time interval from 17:00 to 08:00, analysis of the level of the waste pond in the palm oil mill shows conditions that correspond to safe indicators, namely within the level range of 336-353 cm. However, significant changes occurred starting at 9 o'clock. An increase in the level of the waste pond was recorded due to heavy rain. This condition continued until 12 o'clock, namely the waste pond level reached 382 cm. When there is a significant increase in the level of waste ponds in palm oil mills, which has the potential for waste overflow, responsive action will be taken by factory employees. In such a scenario, plant personnel will activate backup pumps that are already available and on standby as part of existing emergency plans. This action is taken to prevent the possibility of overflowing waste ponds and maintain the stability of the operational environment.

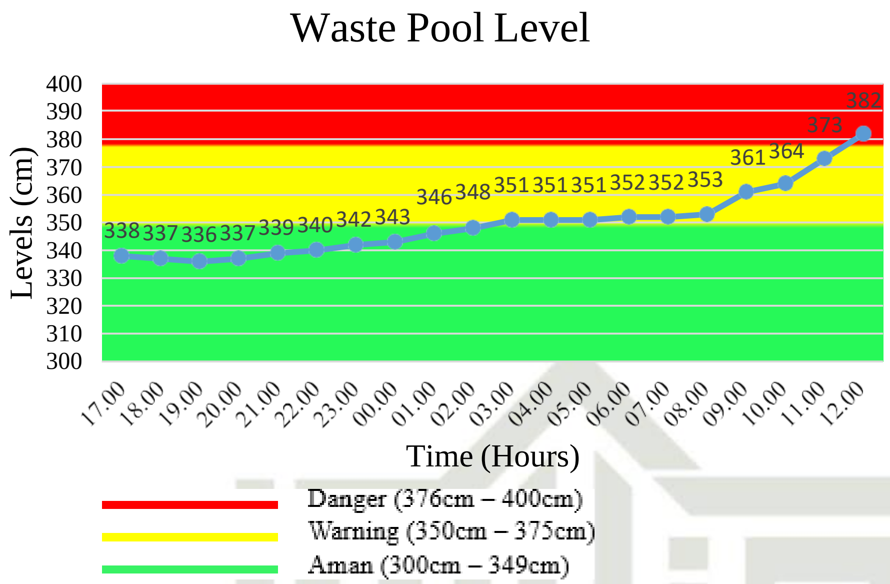


Figure 10. Data recorded in the waste pond level monitoring system

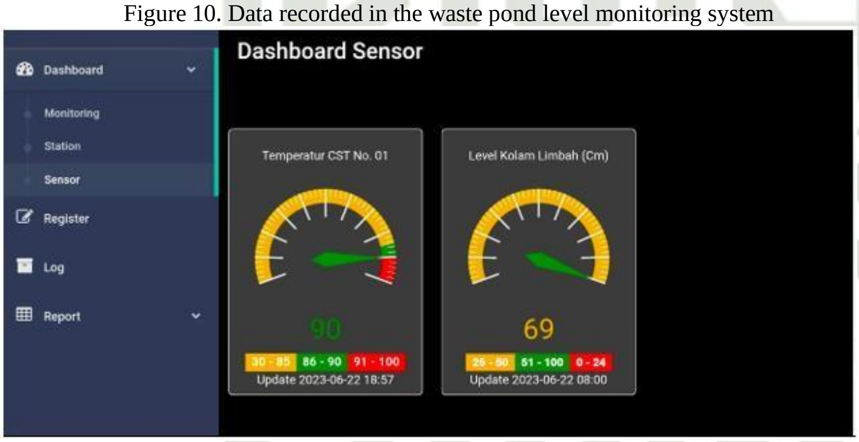


Figure 11. Web sensor dashboard display

Figure 11 is a display of a web-based sensor dashboard that functions as a provider of information or monitors the state of the processing unit being measured through the intermediary sensors available. There are 2 displays, namely CST temperature and waste pond level. The first display is the temperature display of CST No.01, which shows a temperature of 90 °C, which indicates a safe indicator, and the second display is the display of the level of waste pond No.13, which shows the water level is 69 cm from the sensor.

IV. CONCLUSION

Based on the research that has been carried out above, it was concluded that the problems in palm oil mills are less efficient in work activities and high work risks in monitoring CST temperature and waste pond water levels, so a solution was found by adding a remote monitoring sensor, namely the DS18B20 sensor for temperature. CST and HC-SR04 sensors for waste pond levels with the help of data transmission using the NodeMCU ESP8266 microcontroller connected to the web. On these two sensors, each experiment was carried out 5 times with 2 scenarios, namely manual measurements and measurements on the sensor. Then, it was found that the measurement values from these 2 scenarios were the same, and the accuracy level was 100%. This research develops a web-based interface that allows plant employees to monitor CST temperatures and waste pond levels from their mobile devices or computers at locations remote from the plant and save the data to a database website monitoring. The monitoring system in this research is in accordance with its function and objectives, namely real-time monitoring.

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Berdasarkan hasil review, artikel tersebut dinyatakan **DITERIMA** untuk dipublikasikan di Jurnal kami untuk Volume 7, Nomor 1, April 2024

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