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Monitoring System Volume of Crude Palm Oil on Vertical Tank Using Ultrasonic Sensor and Solenoid Valve

B Siregar¹, A Hizriadi¹, MR Faizal¹, Sulindawaty²

¹Dept. of Information Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara

²STMIK Pelita Nusantara, Medan - Indonesia

E-mail: baihaqi@usu.ac.id

Abstract. During this time to find out the volume of Crude Palm Oil (CPO) in the palm oil mill, it was monitored every day on the vertical tank manually using a sounding meter. Monitoring data taken manually is less accurate and requires more time and manpower. So that this weak monitoring data can cause losses if there is oil loss in the tank. Therefore, research aims to help control vertical tanks and can detect any loss of CPO that can harm the company. This research uses data obtained by an ultrasonic sensor connected to a microcontroller and installed solenoid valve on the tank discharge faucet. Data received by the microcontroller is then sent to the server and then stored in the database to be retrieved visually on the monitoring system dashboard. The test results show that the system built can facilitate monitoring of CPO volume in vertical tanks.

1. Introduction

CPO or crude palm oil is what humans need, the use of palm oil can be used as raw material for food, cosmetics, medicine, large industries and small industries. CPO is vegetable oil obtained from the extraction of fruit (mesocarp) from oil palm fruit. Currently CPO is produced through processing in several palm oil mills or often referred to as Pabrik Kelapa Sawit (PKS) owned by large companies. In PKS, CPO is stored in a vertical tank. Currently, the process of monitoring the contents of the tank every day is still done manually by humans every morning to measure the volume of CPO. The problem that often occurs is the discovery of cases when CPO was taken without the knowledge of factory management. Therefore, a CPO monitoring system is needed that can measure the volume of CPO in the tank and can also detect if there is a CPO removal outside the schedule set by the plant management.

Monitoring of vertical tanks that are done manually every day using sounding meters. Sounding meters are useful tools for measuring the depth of the charge of liquids in a vessel or tank such as water, oil, chemicals, and other liquid loads. Because it is done manually, monitoring data is sometimes less accurate. Besides that, it requires more time and manpower to monitor the entire tank in PKS. This weak monitoring can cause losses if there is continuous oil loss from the tank.

In previous research, in 2013 Setiawan conducted research to monitor tank levels at gas stations and detect water levels in the fuel tank telemetry to find out how much gasoline is in the fuel tank using ultrasonic sensors. He also uses a water sensor to automatically open and close the electric faucet to detect water levels in the tank [1]. Yahya in 2013 conducted research to monitor and measure



tanks for multilevel storage. In this research he used a frequency domain-based technique using coaxial geometry for short-circuiting which was inserted vertically in a liquid-filled tank designed and applied to monitor and measure multilevel storage tanks. Research carried out using four different ingredients, namely air, engine oil, water and mud [2]. Wiedjaja, et al in 2012 conducted a study to monitor the water level in the Katulampa dam. This research tool uses an Arduino microcontroller as the main module which is connected with an ultrasonic sensor as a water level detector, and a GSM module for high water data communication media with an SMS type message format [3]. Desai, et. al. in 2016 has conducted research using ultrasonic sensors in terms of experimental settings on a level control system called quadruple / multivariable tank system [4]. Mancilla, et. al. in 2014, it has conducted research using ultrasonic sensors by presenting analysis, design and implementation of liquid level nonlinear controls for tank systems that are combined in series. This system consists of two tanks connected in series, where the output flow from the first is input from the second. Tank liquid level is monitored by ultrasonic sensors. The discharge of the tank is controlled by a proportional valve [5]. In 2011, Gaber, et. al. presents a proposed optical sensor for measuring levels and volumes in an oil tanker tank. They have illustrated the proposed sensor principle and provided some experimental measurement results [6]. In 2011, Brunnader presented our first experimental results for a model-based approach that was able to distinguish the effects of various free volumes in tanks and small ventilation holes and leaks in tank hulls. The results are obtained by considering the lossless parameter estimation value in the equivalent circuit model that corresponds to the actual free volume and the magnitude of the leak [7].

In this research, we use ultrasonic sensors to monitor CPO on vertical tanks. With a system built through this research, it is hoped that it can help control vertical tanks and can detect the possibility of CPO loss that can harm the company. Ultrasonic sensors or often referred to as PING sensors function by changing physical quantities (sounds) into electrical quantities and vice versa. The way this sensor works is based on the principle of a sound wave reflection so that it can be used to interpret the existence (distance) of an object with a certain frequency.

2. Material and Method

General architecture in this research describes the entire components used along with the flow of the process of sending sensing results, which is shown in Figure 1.

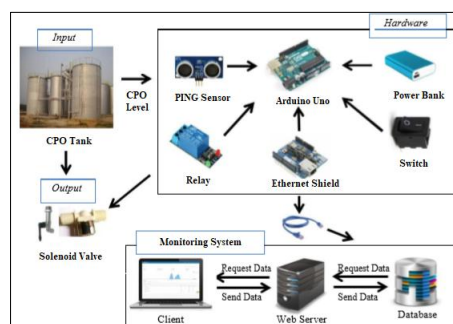


Figure. 1. General Architecture

2.1. System Design

The container used to hold crude palm oil or CPO is fitted with an ultrasonic sensor on the closing side. The ultrasonic sensor is used to measure the volume of CPO in the container for a certain period of time. In the installation of an ultrasonic sensor, the negative leg is connected to the negative voltage and the positive leg is connected to the positive voltage. Then the leg with the SIG sign is connected to the Arduino 8 digital pin. The ultrasonic sensor is mounted on the lid of the CPO container while the solenoid is attached to the pipe at the bottom of the CPO container and the tip of the solenoid is connected to the tap. The solenoid has two legs with one leg connected to the positive 12V voltage of the adapter and another leg is connected to the middle leg of the relay in the large current block.

Whereas the leg parallel to the SIG leg in the small current block is connected to the negative voltage of the adapter. The opening or closing of the valve on the solenoid is determined by the position of the switch. The sensing data sent by the ultrasonic sensor is then read by the microcontroller to then be sent to the server by using an ethernet shield module. The Ethernet shield functions as a medium for sending data through a UTP cable connected to a computer. The Ethernet shield used is paired with the Arduino on the analogue pin and the input / output pin on the Ethernet shield just above the analogue pin and the input / output pin on the Arduino, and the digital pin on the Ethernet shield just above the digital pin on the Arduino. A 5V power bank is connected to Arduino using a USB cable.

In the switch installation, one leg switch is connected to a positive voltage and another leg is branched with one part connected to the digital pin 7 on the Arduino with another is connected to the first leg on the 10k Ω resistor. The second leg is branched with one part connected to the negative leg of the led and the positive leg of led is connected to the digital pin 6 on the Arduino. Then one part of the 10k Ω resistor that was previously connected to the second led negative leg and the positive leg of the second led was connected to the Arduino 9 digital pin. While the negative leg of the second led is connected to the negative voltage. The switch is used to open or close the solenoid valve that is when the switch is active (I) then Arduino will send the value 0 to the relay so that the valve on the solenoid will be closed. Then Arduino will send data in the form of height of CPO with a value of 1. While if the switch is inactive (O) then Arduino will send value 1 to the relay so that the valve on the solenoid will open and Arduino will send data in the form of height of CPO with a value of 0.

In the relay installation, there are two pin blocks where one block for small currents and other blocks for large currents. In small current blocks there are legs VCC, GND and SIG. The VCC leg is connected to the positive voltage, the GND leg is connected to the negative voltage, and the SIG leg is connected to the digital pin 2 on the Arduino. All positive voltages are combined and connected to the Arduino VCC pin and all negative voltages are combined and connected to the Arduino GND pin. As a power source for Arduino a power bank is used which has an output voltage of 5V, while as a solenoid voltage source an adapter has an output voltage of 12V. The results of Arduino, relay, switch, led, ethernet shield, and ultrasonic sensors can be seen in Figure 2.

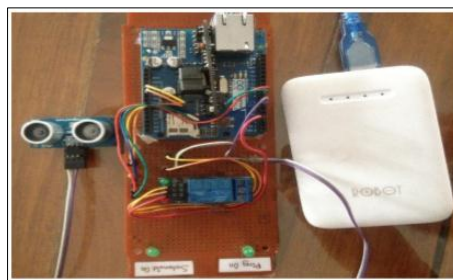


Figure 2. Hardware System

In the monitoring system there are two parameters that will be sent to the server namely the water level and the status of the solenoid. These data are sent to the server by using an Ethernet shield that is connected to Arduino. The sensing data that will enter the database is then processed and displayed to the user in the form of information on volume values and graphics displayed periodically. Data transmission flowcharts can be seen in Figure 3.

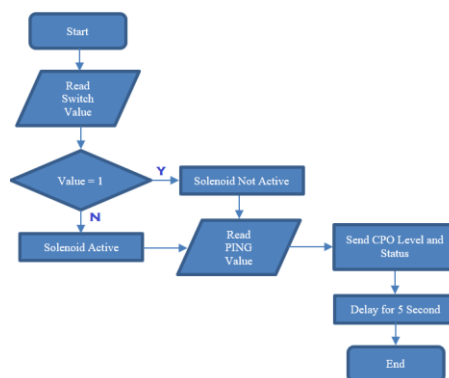


Figure 3. Data Transmission Flowchart

The explanation of Figure 3 is as follows:

- At starting, Arduino will read the value of the switch where the switch has two values, namely 1 and 0;
- If the switch value is equal to 1, the solenoid valve will not be opened in other words, CPO will not be removed from the tank;
- If the switch value is equal to 0 then the solenoid valve will be opened in other words CPO can be removed from the tank;
- After the process of activating or deactivating the solenoid, Arduino will read the value of the ultrasonic sensor;
- After the ultrasonic value reading process, Arduino will send data to the server in the form of CPO volume and solenoid status by using an ethernet shield;
- After the process of sending data, Arduino will repeat the process from the beginning after 5 seconds has passed.

2.2. Hardware Components

The hardware components used are as follows:

- Ultrasonic sensor or PING sensor, consisting of a chip that functions as a 40kHz signal generator, an ultrasonic speaker and an ultrasonic microphone. The 40kHz signal received by the ultrasonic speaker is converted into sound then the function to capture the sound reflection is the ultrasonic microphone. The PING sensor will give a pulse output which is a representation of distance. The output in the form of pulses generated by the PING sensor has a pulse width that varies from 115μs to 18.5ms. In this research PING sensor brand Parallax is used.
- Solenoid valve, used as a distributor and breaker of water flow in a water channel. Basically, a solenoid has a valve driven by electricity. Inside the solenoid valve there is a plunger that is driven by a coil when given an electric current. Part of the solenoid valve is the output hole, insert hole, air trap hole (exhaust) and the main inlet hole.
- Arduino Uno, in the form of an ATmega328 microcontroller board.
- Ethernet shield, is a module that can be used to send data to other devices using an RJ45 connector.
- Relay, is a switch that requires electricity to operate it. It is also an electromechanical component that has two main parts namely electromagnet (coil) and mechanical which is a set of switch contacts. To move the switch contacts the electromagnetic principle is used in a relay so that with a small current can conduct electricity with a higher voltage. The use of relays is very important for electrical or electronic circuits in moving devices that require large currents without being directly connected to a controlling device that has a small current. In other words, the relay also functions as a security.

2.3. Web Server

The web server functions as a service provider and processing data between Arduino, databases, and client dashboards. The web server will receive data from Arduino in the form of CPO volume in the tank. Every change in volume, the data will enter the server and then checked with a schedule, according to the spending schedule or not. Visualization in graphical form is updated regularly for every 5 seconds.

3. Result and Discussion

The results of the system design that has been built are as follows:

3.1. Main Dashboard Page

As shown in Figure 4, this page is displayed after the user has logged on. This page shows the total data of CPO that came out, the total number of schedules, and the total amount of CPO that had entered the tube. In addition, the dashboard also displays moving graphs for sensor data that enter the database.

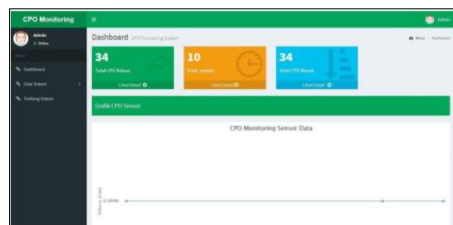


Figure 4. Main Dashboard

3.2. Information for CPO Exit

On this page, users can see information about CPO coming out of the tank, namely the amount of CPO coming out, the total volume of CPO coming out, and the average volume of CPO coming out. As shown in Figure 5.

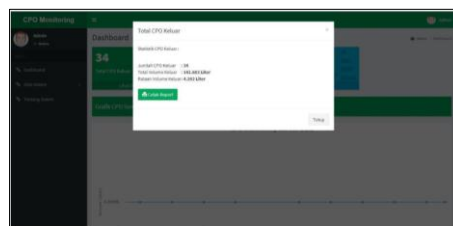


Figure 5. CPO Exit Information

3.3. Scheduling Setting

As shown in Figure 6, on this page the operator can set the schedule for taking CPO oil from the tube. This data is used as an indicator of the condition whether the reduction or withdrawal of CPO oil is carried out on schedule or not.

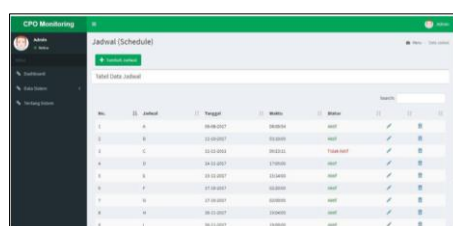


Figure 6. Setting for Scheduling

3.4. System Testing

System testing is carried out to determine the performance of the system when monitoring CPO exit from the valve whether it is on schedule or not by utilizing the XOR function, with the final result in the form of four status types as shown in Table 1.

Table 1. Status for Scheduling of CPO Exit

No.	Normalization	Status
1	(1,1)	reduced, on schedule
2	(0,1)	not reduced, on schedule
3	(1,0)	reduced, not on schedule
4	(0,0)	not reduced, not on schedule

4. Conclusion

- The accuracy of the CPO volume measuring system in the tank using ultrasonic sensors obtained an average difference of 23.7% lower than the volume measurement using sounding meters.
- Detection of open or not valves according to the specified schedule has a success of 100%.

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