Journal of Telematics and Informatics (JTI)
Vol.7, No.1, March 2019, pp. 38~45
ISSN: 2088-8708

MONITORING THE USAGE OF MARINE FUEL OIL ABOARD PASSANGER SHIP BASED ON *INTERNET OF THINGS*

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Abstract

Measurement of the remaining MFO oil in the tank when the ship is sailing makes the crew become more troublesome because it must be reported within a certain period of time, for example every once an hour using a pendulum sensor. The measurement using this pendulum sensor the accuracy and precision of each becomes a deficiency of the value produced because the position of the ship is not taken into account. Another disadvantage of conventional methods is that fraud can occur if the tank capacity is full by manually falsifying measurement data, then MFO can be sold in the middle of the sea to fishermen or smuggled illegally to an outside country. To overcome these problems, the need for special monitoring for the availability of MFO oil in tanks by ship-owners needs to be carried out. In this case the accuracy, precision and the need for data that is always displayed and known by ship-owners is very important for the business management process of the company. For that, a precise, accurate and real-time fuel consumption monitoring tool is needed. As a comparison, manual measurement of appeal sensors was also carried out in order to get a more significant comparison value. There are 4 HC-SR04 ultrasonic sensors needed to get accuracy and precision on the position of the ship such as horizontal, tilted to the right, tilted to the left with a slope of 8 degrees and 16 degrees. The test results have shown that the four HC-SR04 sensors are able to read more accurate than the pendulum sensors in various ship positions. The reading result with HC-SR04 sensor has an error below 5% compared to an error in the pendulum sensor of 7.5%. Then, the mean error on the surface of the tank with the condition of a flat vessel of 2, 08%, on the position of the tilted vessel of 2.17% and the condition of the ship with a bumpy wave of 3.35%. The results of the measurement of the MFO volume in the tank sent through the internet to the monitoring station can be perfectly received so that it becomes accurate and real-time information for the observation of fuel consumption by the company management. Thus the prototype of monitoring the use of MFO fuel on passenger ships can be used to replace conventional measurement models which use pendulum sensors.

Keywords **:** *Arduino Uno, Ultrasonic Sensor, Potentiometer Pendulum Sensor, Esp 8266*

1. Introduction

The development of the shipping industry in Indonesia has continued to increase in the past 10 years. This development can be seen from the increasing number of national vessels. The number of national vessels increases from 6,041 units in 2005 to 24,046 units in 2016 [1]. The number of ships owned by ship owners in Indonesia is more and more after the existence of Law No. 17 of 2008 which is about the sabotage principle. Sabotage principle is a strategy of empowering national sea transport that provides a conducive climate in order to promote the transport industry in the waters, among others, in the field of taxation, and capital in the procurement of vessels and the existence of long-term contracts for transport in waters [2].

The more number of vessels owned makes its own problems for ship owners. One of the problems faced is the way to monitor the performance of the vessel because each ship has different travel routes. During this monitoring of the ship is done by analyzing data from records made by ABK. This method has a weakness of human error made (by shipmans crew) in making report and data from the new ABK was obtained when the ship was leaning.

Many data reported by shipmans crew to the ship owner company. One of the data reported was the use of Marine Fuel Oil (MFO). MFO usage reports are important because they affect production cost calculations by management. To avoid reporting errors and in order management gets information as soon as possible against the use of MFO on board, this study made a tool that could monitor the use of MFOs aboard the ship from a far-distance.

One of previous researches which underlined this research was research to make ship balance monitoring systems wirelessly using Bluetooth [3]. The sensor used to read the slope of the ship is the IMU sensor. The data from the IMU sensor is sent via Bluetooth to the android system. This system can be used with a maximum distance of 30 meters. Another study was to measure temperature and humidity in agriculture [4]. The module used to measure temperature and humidity is DHT11. Data from DHT11 is sent via Short Message Service (SMS) when there is data request via SMS. In addition, the built system can send SMS automatically to the farmer when the soil moisture is less and the system turns on the pump automatically to water the ground.

Previous studies related to the monitoring of fuel consumption were volume monitoring and water clarity in Lab View based tanks with Ni Myrio controller [5]. This research monitored the volume of water in the tank using ultrasonic sensors and water clarity using turbidity sensors. Readout data from the sensor is sent to personal computer (PC) via wireless. The result of SRF 04 ultrasonic sensor reading in the form of volume displayed in PC as simulation of water level condition in tank. While the readout data from turbidity sensor is displayed on the PC in the form of nominal score of water clarity.

2. Architecture System Model

The working system in this study was that 4 HC - SR04 ultrasonic sensors read the height of MFO in the tank continuously. The height datas of MFO in the tank from the front, rear, right and left ultrasonic sensors are converted by Arduino Uno into volume data by taking the average distance from the four sensors then converted into MFO volume data in the tank. Besides, potentiometer pendulum sensor would read the volume of MFO in the tank continuously using the linear equation first. Volume data and time information data from RTC were sent continuously to the user's computer that was in a remote place via the wifi transceiver. By the computer the user displayed the date, time, ultrasonic HC - SR04 volume and volume of the potentiometer pendulum. Architecture system model on this study as shown in Figure 1.

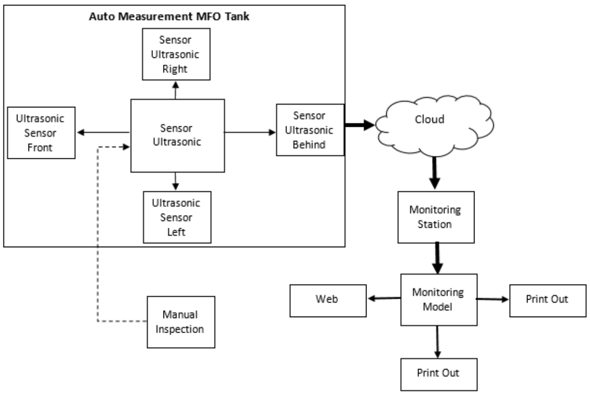


Figure 1. Architecture System Model

A miniature tank which represent the actual MFO tank has been setup. Miniature MFO tank has dimensions of 50 cm long, 20 cm wide and 23cm high, as shown in Figure 2.

Figure 2. MFO Miniature Tank

Based on the diagram block, this study used hardware which has the following functions : Ultrasonic sensor is a measure of MFO surface distance with position of ultrasonic sensor being placed. The potentiometer pendulum sensor is a measure of MFO surface distance with the position of the potentiometer pendulum sensor being placed. RTC is a timing information system related to seconds, minutes, hours, days, months, and years when taking the data. The controller is the overall system control center. The controller processes the data from the potentiometer pendulum sensor and the ultrasonic sensor and the timer system from the RTC which is then sent to the LCD and the user's computer. Wi-Fi shield 8266 is as a medium of wireless communication between the microcontrollers to the internet. I2C (Inter-Integrated Circuit) is a serial communication media with a cable between microcontroller to LCD. The LCD is the display of MFO volume near the MFO tank. The user's computer is a remote view of MFO volume (from a distance).

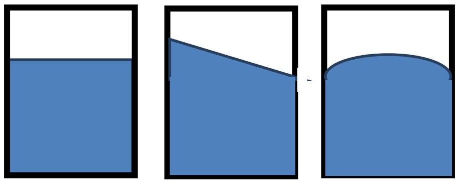


Figure 3. MFO's Flat, Sloping and Wavy Surfaces

This research was conducted in the Marine Merchant Academy of Surabaya laboratory using a miniature MFO tank with a size of 50 cm long, 20 cm wide and 23 cm high as in Figure 2. Measurements are carried out by filling in a tank miniature every 0.5 liters starting at a volume of 5 liters to 12 liters. Retrieval of data is taken when the surface of the MFO has calmed well when flat, right tilt 80, right 160, left 80, and left 160, and wave. Readable volume data is sent via the hotspot network to the website using Telkomsel's cellular network. The speed for uploading volume data to the website is 251 kB / s

3. Results And Analysis

The test was done by using two types of sensors to measure the volume, namely HC - SR04 ultrasonic sensor and potentiometer pendulum sensor. In addition to using 2 types of sensors, testing was also done with a flat, sloping, and wavy MFO surface as shown in Table 1.

Table 1. Result Data of Ultrasonic Sensor Testing

MFO Surface	Gauge Glass (Liter)	HC - SR04 Ultrasonic Sensor (Liter)	Error (%)	Potensiometer Pendulum Sensor (Liter)	Error (%)
Flat	5	5.17	3.29	6.9	27.54
	5.5	5.69	3.34	6.9	20.29
	6	6.18	2.91	6.9	13.04
	6.5	6.72	3.27	6.9	5.8
	7	7.19	2.64	6.94	0.86
	7.5	7.69	2.47	7.58	1.06
	8	8.17	2.08	7.9	1.27
	8.5	8.64	1.62	8.51	0.12
	9	9.14	1.53	9.01	0.11
	9.5	9.65	1.55	9.57	0.73
	10	10.15	1.48	9.9	1.01
	10.5	10.66	1.5	10.15	3.45
	11	11.2	1.79	10.15	8.37
	11.5	11.17	2.95	10.15	13.3
	12	12.15	1.23	10.15	18.23
8^0 right	5	5.18	3.47	6.9	27.54
16^0 right		5.22	4.21	6.9	27.54
8^0 left		5.2	3.85	6.9	27.54
16^0 left		5.25	4.76	6.9	27.54

8^0 right	5.5	5.68	3.17	6.9	20.29
16^0 right		5.7	3.51	6.9	20.29
8^0 left		5.73	4.01	6.9	20.29
16^0 left		5.69	3.34	6.9	20.29
8^0 right	6	6.15	2.44	6.9	13.04
16^0 right		6.19	3.07	6.9	13.04
8^0 left		6.16	2.6	6.9	13.04
16^0 left		6.21	3.38	6.9	13.04
8^0 right	6.5	6.66	2.4	6.9	5.8
16^0 right		6.74	3.56	6.9	5.8
8^0 left		6.68	2.69	6.9	5.8
16^0 left		6.77	3.99	6.9	5.8
8^0 right	7	7.2	2.78	6.9	1.45
16^0 right		7.25	3.45	6.9	1.45
8^0 left		7.17	2.37	6.9	1.45
16^0 left		7.23	3.18	6.9	1.45
8^0 right	7.5	7.64	1.83	7.25	3.45
16^0 right		7.7	2.6	7.18	4.46
8^0 left		7.67	2.22	7.3	2.74
16^0 left		7.71	2.72	7.22	3.88
8^0 right	8	8.14	1.72	8.38	4.53
16^0 right		8.2	2.44	8.31	3.73
8^0 left		8.16	1.96	8.37	4.42
16^0 left		8.24	2.91	8.33	3.96
8^0 right	8.5	8.69	2.19	8.72	2.52
16^0 right		8.75	2.86	8.69	2.19
8^0 left		8.68	2.07	8.75	2.86
16^0 left		8.77	3.08	8.67	1.96
8^0 right	9	9.15	1.64	9.21	2.28
16^0 right		9.21	2.28	9.17	1.85
8^0 left		9.13	1.42	9.25	2.7
16^0 left		9.17	1.85	9.17	1.85
8^0 right	9.5	9.66	1.66	9.7	2.06
16^0 right		9.72	2.26	9.64	1.45
8^0 left		9.65	1.55	9.71	2.16
16^0 left		9.71	2.16	9.65	1.55
8^0 right	10	10.14	1.38	10.15	1.48
16^0 right		10.18	1.77	10.13	1.28
8^0 left		10.16	1.57	10.15	1.48
16^0 left		10.19	1.86	10.11	1.09
8^0 right	10.5	10.67	1.59	10.15	3.45
16^0 right		10.73	2.14	10.15	3.45
8^0 left		10.64	1.32	10.15	3.45

16^0 left		10.71	1.96	10.15	3.45
8^0 right	11	11.18	1.61	10.15	8.37
16^0 right		11.24	2.14	10.15	8.37
8^0 left		11.15	1.35	10.15	8.37
16^0 left		11.2	1.79	10.15	8.37
8^0 right	11.5	11.66	1.37	10.15	13.3
16^0 right		11.73	1.96	10.15	13.3
8^0 left		11.64	1.2	10.15	13.3
16^0 left		11.71	1.79	10.15	13.3
8^0 right	12	12.13	1.07	10.15	18.23
16^0 right		12.18	1.48	10.15	18.23
8^0 left		12.14	1.15	10.15	18.23
16^0 left		12.2	1.64	10.15	18.23
Wavy	5	5.25	4.76	6.9	27.54
	5.5	5.76	4.51	6.9	20.29
	6	6.3	4.76	6.9	13.04
	6.5	6.75	3.7	6.9	5.8
	7	7.28	3.85	7.32	4.37
	7.5	7.76	3.35	7.84	4.34
	8	8.32	3.85	8.45	5.33
	8.5	8.85	3.95	8.83	3.74
	9	9.28	3.02	9.37	3.95
	9.5	9.77	2.76	10.01	5.09
	10	10.33	3.19	10.15	1.48
	10.5	10.74	2.23	10.15	3.45
	11	11.26	2.31	10.15	8.37
	11.5	11.73	1.96	10.15	13.3
	12	12.22	1.8	10.15	18.23

Table 1, shown that data testing for the HC - SR04 ultrasonic sensor, it can be seen that using HC - SR04 ultrasonic sensor in all test volumes and all surfaces of the field could be measured properly because it had an error of less than 5%, except on the surface of the waveform which could produce error more than 5% on all test volumes. The error generated from the HC - SR04 ultrasonic sensor on the flat surface for the largest was 3.34% (volume measuring of 5.5 liters) and the smallest error was 1.23% (volume measuring of 12 liters), and the average was 2.08%. HC - SR04 ultrasonic measurements on sloping surfaces produced the biggest error of 4.76% (volume measuring of 5 liters with 160 slopped to the right) and the smallest error was 1.15% (12 liters of measurement with 80 slopped to the right) and the average error was 2.17%. HC - SR04 ultrasonic measurement for wavy fields has the biggest error of 4.76% (5 liters' volume measurement) and the smallest error was 1.80% (12 liters' volume measurement) and the average error was 3.35%.

On the use of HC - SR04 ultrasonic sensor for volume measurement on flat field was different between 0.14 liters to 0.33 liters compared to the actual volume and the average difference was 0.17 liters. While the difference in the sloping field between 0.13 liters to 0.27 liters with an average difference of 0.19 liters, and the difference in the wavy field was between 0.22 liters to 0.35 liters with an average difference of 0.26 liters to the actual volume. If it is seen the difference in volume when used for measurement in all fields for flat, sloped, and wavy fields, the HC - SR04 ultrasonic sensor has almost the same score.

Test results for the potentiometer pendulum sensor to measure the test volume on the field with flat, slopped, and wavy surfaces indicate that the potentiometer pendulum sensor cannot read well for several test volumes in flat, slopped or wavy fields. This is evidenced by the error results of more than 5% for several test volumes with flat fields, slopped fields and wavy fields. On a flat field, the biggest error occurred at a 5 liters volume measurement of 27.54% and the smallest error when measuring 9 liters was 0.11% and the average error was 3.45%. For measurements on sloping surface, the biggest error occurs when measuring a volume of 5 liters with all slopes of 27.54% and the smallest error occurs when measuring 10 liters with a sloping degree of 16^0 to the right of 1.09% and the average error on the sloping surface was 4.44%. On testing with the surface of the wavy field, the biggest error occurs when measuring the volume of 5 liters was 27.54% and the smallest error when measuring the volume of 10 liters was 1.48% and the average error on the surface of the wavy field was 5.33%.

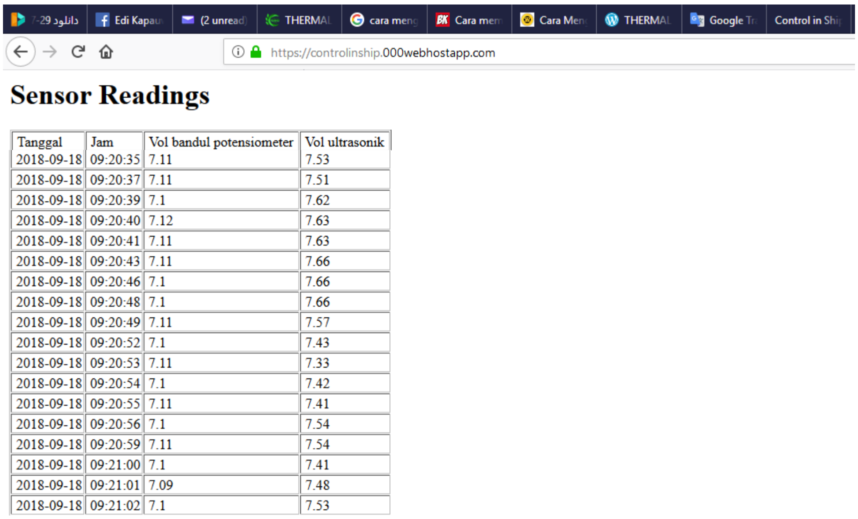
The difference in volume measured using a potentiometer pendulum with a volume sensor actually shows that the most difference and the least difference have a considerable distance. On a flat surface the biggest difference was 1.9 liters when measuring a volume of 5 liters and the smallest difference is 0.01 liters with the average difference in flat surface testing was 0.35 liters. On the sloping surface the biggest difference when measuring a volume of 5 liters with all slopes of 1.9 liters and the smallest difference when measuring a volume of 7 liters with all slopes of 0.1 liter, and the average difference on the sloping surface was 0.36 liters. While on the wavy surface the biggest difference when measuring the volume of 5 liters was 1.9 liters and the smallest difference when measuring 10 liters was 0.15 liters with the average difference on the wavy surface was 0.45 liters to the actual volume.

The results of the comparison for the use of HC - SR04 ultrasonic sensor with a potentiometer pendulum sensor as a whole shown that the HC - SR04 ultrasonic sensor can be used on all test volumes and all field surfaces of flat, slopped and waveform. While the potentiometer pendulum sensor can only be used on a volume of 7 liters to 10 liters in almost all surfaces of the fields, flat, slopped or wavy because it has an error which is not greater than 5%. This is because the potentiometer pendulum sensor has a limited work area that is the minimum volume that can be read is 6.9 liters and the maximum volume that can be measured is 10.15 liters.

Comparison of the measurement results of HC - SR04 ultrasonic sensor with potentiometer pendulum sensor in volumes between 7 liters and 10 liters on flat and slopped surfaces indicates that the potentiometer pendulum sensor has an average error better than HC - SR04 ultrasonic sensor. On a flat field, the average error generated by the potentiometer pendulum sensor was 0.86% while the HC-SR04 ultrasonic sensor was 1.62%. In the sloping surface, the average potentiometer pendulum error sensor was 2.11% while the average of HC-SR04 ultrasonic sensor error was 2.17%. In the volume measurement in the wavy field by the potentiometer pendulum sensor was still less good than the HC - SR04 ultrasonic sensor, where the average error of the potentiometer pendulum sensor was 4.34% while the average error of the HC - SR04 ultrasonic sensor was 3.35%

Figure 4. Display Date,Time, Volume Using Ultrasonic Sensor And Potensiometer Pendulum Sensor On LCD

Data from ultrasonic sensors and potentiometer pendulum sensor are converted into volume data by the Arduino Uno. Then the volume data is sent to LCD via I2C using serial communication. Volume data of ultrasonic sensors is displayed in row 0 column 11 and volume data of potentiometer pendulum sensor is displayed in row 1 column 11. In addition to volume data from both types of sensors, the Arduino Uno also sends data in the form of date and time obtained from the RTC module to the LCD. Communication between RTC and Arduino Uno also uses serial communication. The date is displayed on the LCD on the row 0 column 0 and the hour on the row 0 column 1.



Sensor Readings

Tanggal	Jam	Vol bandul potensiometer	Vol ultrasonik
2018-09-18	09:20:35	7.11	7.53
2018-09-18	09:20:37	7.11	7.51
2018-09-18	09:20:39	7.1	7.62
2018-09-18	09:20:40	7.12	7.63
2018-09-18	09:20:41	7.11	7.63
2018-09-18	09:20:43	7.11	7.66
2018-09-18	09:20:46	7.1	7.66
2018-09-18	09:20:48	7.1	7.66
2018-09-18	09:20:49	7.11	7.57
2018-09-18	09:20:52	7.1	7.43
2018-09-18	09:20:53	7.11	7.33
2018-09-18	09:20:54	7.1	7.42
2018-09-18	09:20:55	7.11	7.41
2018-09-18	09:20:56	7.1	7.54
2018-09-18	09:20:59	7.11	7.54
2018-09-18	09:21:00	7.1	7.41
2018-09-18	09:21:01	7.09	7.48
2018-09-18	09:21:02	7.1	7.53

Figure 5. Display Date,Time, Volume Using Ultrasonic Sensor And Potensiometer Pendulum Sensor On Website

The results data in this study can be displayed on the https://controlinship.000webhostapp.com website by using a wifi network. Volume data from both types of sensors, date data and hours data is sent to Wemos by Arduino Uno using serial communication Tx and Rx. These data are sent to the website via a WiFi network that is connected to the internet using ESP 8266. Any changes to the data will be displayed on the website as long as the Arduino Uno can connect to the internet via a WiFi network.

4. CONCLUSION

Based on the results of the tests conducted, this study can take some conclusions that the HC-SR04 ultrasonic sensor can be used on all volumes and all surface fields such flat, slopped and wavy. Potentiometer pendulum sensors can be used at a limited volume of 7 liters to 10 liters. The potentiometer pendulum sensor is better than the HC - SR04 ultrasonic sensor when the work area is between 7 liters and 10 liters except for wavy conditions. HC - SR04 ultrasonic sensor is better when used for tanks that have dimensions of high altitude because the work area or range of HC - SR04 ultrasonic sensor is longer than the potentiometer sensor pendulum. The potentiometer pendulum sensor is better when used for tanks that have dimensions of low altitude because the work area or sensor range of the pendulum is shorter but has better accuracy than the HC - SR04 ultrasonic sensor. The prototype for monitoring the volume of MFO on board uses HC-SR04 ultrasonic sensor and a potentiometer pendulum sensor can be done. The test results showed that the HC - SR04 ultrasonic sensor and the potentiometer pendulum sensor can transmit data in the form of volume. The implementation of IoT in monitoring the volume of MFO on board can be done. The test results showed that the computer’s users in a distance location from the ship can display on the screen in the form of volume data on the ship. The results of this study can reduce management costs to monitor directly to the ship because it can be done online from the computer’s users.

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