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Design an Internet of Things Simulator of Fluid Volume Monitoring System for Petrol Station Underground Tank

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Abstract

Objectives: This study aims to design an internet of things simulator of fluid volume monitoring system. **Methods:** The method used in this research includes simulator design and simulator testing. Monitoring system using an ultrasonic sensor, nodeMCU, ThingSpeak, and Virtuino. The value of ultrasonic sensors will be processed in the NodeMCU program resulting liquid level in the buried tank then sent through the internet to ThingSpeak. **Findings:** The result of monitoring the liquid level in a buried petrol station simulator uses ultrasonic sensor HCSR04P and NodeMCU v.1.0 from 08.00 pm to 02.00 am displayed on the site ThingSpeak with value 17.42 L.Setting alarm on Virtuino at 50% of maximum volume of 8.8 L. The experimental results the volume of fluid reduction 8.09 L has managed to activate alarm on the application Virtuino. **Applications:** This internet of things simulator of fluid volume monitoring system applicated for the petrol station underground tank.

Keywords: Internet of Things, Simulator, Fluid Volume, Monitoring System, Petrol Station, Underground Tank.

1. Introduction

The number of vehicles in the street increases rapidly. The petrol station facilitates the public to meet fuel needs [1]. Petrol station receives fuel supply from the nearest depot delivered using a measuring tank car, in Indonesia is called TUM. The Petrol station has a buried storage tank for fuel. Buried tank belongs to the type of fixed cylindrical measuring tank and sets in The Decree of Directorate General of Standardization and Consumer Protection Number 252 (2013) about Technical Requirements of Upright Fixed Cylinder Shape Measuring Tank. Currently, most of the volume examination for the availability of petrol station is conducted by measuring the liquid level manually using depth stick. The calibration data of the tank dimension, which is collected from the beginning before the tank was buried. Internet of things (IoT) technology serves to collect data generally by each of the objects connected to the internet to be processed and analyzed it into useful information and used to control and monitor these objects [2–3]. It can be used to facilitate the measurement of fluid height in the tank and by using the equation that related to the tank, the fluid volume [4] in the tank become countable automatically. There are several previous studies that designed the tank liquid level monitoring system for the buried tank. The monitoring system designed by using microcontroller-based ultrasonic waves [5–7], the use of ThingSpeak as the internet of things server [8–9] as well as IP address by using a Wifi module NodeMCU [10–12]. Thus, this study will be designed as a system of monitoring the liquid level in the buried tank based on the internet of things, thus the management of fuel supply in the petrol station becomes more efficient and effective.

2. Materials and Methods

The method used in this research includes literature review, simulator design, simulator testing and data analysis, and conclusions. Figure 1 shows the flow chart.

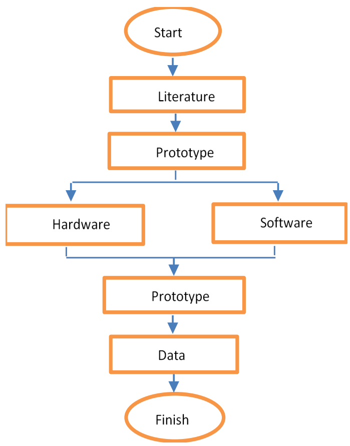

FIGURE 1. Flowchart of research.

Figure 2 describes the block diagram of the monitoring system. The value of ultrasonic sensors will be processed in the NodeMCU program resulting liquid level in the buried tank, then they sent through the internet to ThingSpeak to display and analyze.

The liquid level shows the difference between the height of the reference and the tank while an empty space defined in the notation M. Altitude reference (T) shows distances from the sensor to the bottom of the tank measured by a steel ruler. Having obtained the value of liquid level and then (1) in the technical requirement was used to obtain a buried tank volume.

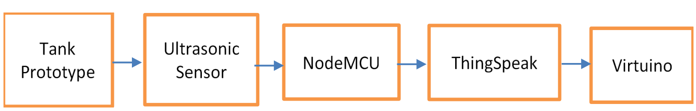

FIGURE 2. Block diagram of a monitoring system.

$$Buried\ Tank\ Volume = \left(K_s \,.\, V_s\right) + \left(K_t \,.\, V_t\right) \tag{1}$$

The buried tank is divided into two main parts. V_s is the volume of the cylinder part and V_t is the volume of the cylinder cover section. K_s, K_t, and P value were obtained from (2), (3), and (4) below.

$$K_s = \frac{1}{\pi}\left\{\cos^{-1}\left(1-2P\right) - 2(1-2P\sqrt{P\left(1-P\right)}\right\} \tag{2}$$

$$K_T = 3P^2 - 2P^3 \tag{3}$$

$$P = \frac{M}{D} \tag{4}$$

D is the diameter of cylinder circumference measurements obtained from the testing point in Virtuino application designed to display the current, illustration liquid in the tank and the graph of tank height on time. After the design and manufacture of the completed multiple calibrations testing, tilt testing, testing on different liquids, the test with the bar in the tank, testing the slope of the tank, volume monitoring, and alarm testing.

3. Results and Discussion

The following data from ultrasonic sensor calibration using a standard steel ruler in Table 1. In [1,5], calibration data were obtained using a steel ruler for SRF05 ultrasonic sensor. An average error of 6 test points 5, 10, 15, 20, 25, and 30 cm was 0.52% with a standard deviation 0.01 cm. It was showed that error value using the SRF05 sensor [1,5] smaller than the HCSR04P sensor in Table 1 as 0.62%. However, both sensors show the same result of the standard deviation.

TABLE 1. Ultrasonic sensor calibration data

Length of steel ruler (cm)	The average length of the sensor (cm)	Error (%)	Maximum hysteresis (cm)
5.01	5.03	0.4	0.10
10.01	10.20	1.90	0.10
15.01	14.93	0.53	0.00
20.01	20.13	0.60	0.00
25.01	25.04	0.12	0.00
30.01	29.95	0.20	0.00

Testing of slope on ultrasonic sensor using a protractor with test point 10 cm. Based on the calibration certificate, the steel bar at a point 10 cm has an actual length of 10.10 cm. The error value obtained at the angle of inclination was displayed in Table 2. Table 2 shows the length was measured by the sensor indicates the larger value due to a significant increase in the tilt angle of the measurement. Altitude beaker glass contains fuel and water as 35 cm. Beaker glass sized 500 mL with 5 mL scale used as a height test point using a

TABLE 2. The testing slope of an ultrasonic sensor

Angle (°)	Length of steel ruler (cm)	The average length of the sensor (cm)
0	10.10	10.28
50	10.10	10.98
100	10.10	11.19
150	10.10	13.40

calibrated steel ruler. Measurement liquid density using Metler Toledo density meter 30px. Density was measured three times for fuel as 0.726 g/cm^3 and water as 0.986 g/cm^3. The effect of density on length measurement displayed in Tables 3 and 4.

TABLE 3. Effect of water density on length measurement

Length of steel ruler (cm)	The average length of the sensor (cm)	Error (%)
5.01	4.75	5.19
10.01	9.88	1.30
15.01	14.83	1.20
20.01	20.12	0.55
25.01	25.04	0.12

TABLE 4. Effect of fuel density on length measurement

Length of steel ruler (cm)	The average length of the sensor (cm)	Error (%)
5.01	4.64	7.39
10.01	10.14	1.30
15.01	14.86	1.00
20.01	20.15	0.70
25.01	25.02	0.04

Tables 3 and 4 show that types of liquids affect length measurements due to different density of both liquids. The higher density of water provides better length measurement results than fuel. Measurement data in Table 5 were obtained using pocket meter and coating thickness gauge.

TABLE 5. Tank specification

Variable	Value
The diameter of the cylinder (D)	23.85 cm
The diameter of the connection (D_s)	22.14 cm
Length of the cylinder (y)	32.97 cm
Length of the cylinder cap 1 (psl_1)	3.60 cm
Length of the cylinder cap 2 (psl_2)	3.50 cm
V_s	17455.70 cm^3
V_t	0.28 cm^3

Error measurement of M and V was conducted by using a steel ruler with an ultrasonic sensor and Arduino IDE program. Fluid-filled from height 5 cm to value of D. Tables 6 and 7 show that the error value average of M is 0.70% and error value average of V is 1.16%. This difference caused by float data type that has range 3.4×10^{-38} to 3.4×10^{38} while calculation indicates decimal value. Figure 3 shows that fluid volume monitoring with ThingSpeak, the value of M at 23.43 cm and the value of V at 17.42 L. Testing of tank slope using a protractor with tilt angle variation was shown in Table 8. Measurement error for tank slope shows the better result with minimum error 0.58% at tilt angle 0° and maximum error 3.05% at tilt angle 150°. Test alarm performed after the calibration test on the tank from maximum liquid height 5 cm. The alarm on Virtuino shows value 8.8 L as displayed in Figure 4.

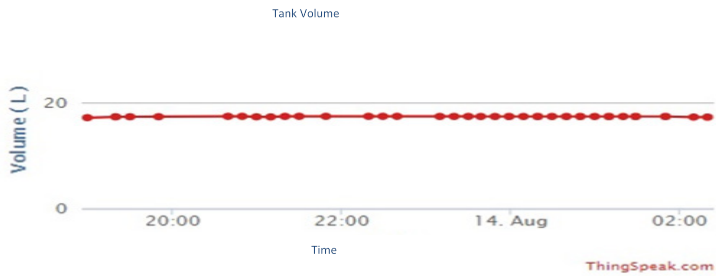

FIGURE 3. Fluid volume monitoring.

TABLE 6. Ultrasonic sensor error for the value of M

Length of steel ruler (cm)	The average length of the sensor, M (cm)	Error (%)
5.01	5.03	0.4
10.01	10.20	1.90
15.01	15.03	0.13
20.01	19.95	0.30
23.61	23.43	0.76

TABLE 7. Ultrasonic sensor error for the value of V

Volume (L)	The average volume of the sensor, V (L)	Error (%)
2.69	2.68	0.37
7.05	7.13	1.13
11.76	11.66	0.85
15.90	15.61	1.82
17.71	17.42	1.64

TABLE 8. Tank slope

Angle (°)	Length of steel ruler (cm)	The average length of the sensor (cm)			
		Test 1	Test 2	Test 3	Average
0	24.1	24.15	24.16	24.15	24.15
50	23.8	23.13	23.14	23.13	23.13
100	23.8	23.12	23.12	23.12	23.12
150	23.6	22.88	22.89	22.88	22.88

FIGURE 4. Alarm display.

4. Conclusion

The result of monitoring the liquid level in a buried petrol station simulator uses ultrasonic sensor HCSR04P and NodeMCU v.1.0 at 08.00 pm to 02.00 am displayed on the site ThingSpeak with value 17.42 L.Setting alarm on Virtuino at 50% of maximum volume of 8.8 L. The experimental results the volume of fluid reduction 8.09 L has managed to activate alarm on the application Virtuino.

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