Design of Fuel Monitoring Tool with Runhour Genset and Controlling Genset Room Based on Internet of Things

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***Abstract*— PT Telkom Indonesia, a telecommunications company, relies on Genset as a backup power source when the main power supply fails. To ensure efficient operation, the company uses an internet of things-based monitoring tool that utilizes various sensors. Ultrasonic sensor A02YYUW monitors the fuel level in the tank as it requires a supply of at least 3000L. The PZEM-004T sensor calculates the generator run time and power consumption to ensure it stays within the safe limits of less than 90 minutes per day and <500 kVA. In addition, the monitoring system keeps an eye on the generator room temperature to prevent overheating and component damage with a temperature limit of 36°C. All information collected by the sensors can be accessed through the website, making it easier for personnel to monitor and control maintenance. Test results show the functionality of the system, successfully measuring fuel levels, detecting runtime and power consumption, and controlling the fan through the website. The A02YYUW sensor measured the fuel depth of 82 cm and then converted it to volume, which is 2096 liters. Then, runhours were detected at 13 minutes with a power value that changes based on the load factor from 52.50 vA - 74.50 vA. For the condition of the generator room temperature, the lowest detected is 29.80°C to 40.70°C which requires turning on the fan to stabilize the room temperature.**

***Keywords*— Fuel Level, Generator Set, Internet of Things, Power, Runhours, Temperature.**

I. INTRODUCTION

The reliability of telecommunication networks is highly dependent on the continuity of electrical power supply. Any interruption in power availability may cause service outages, data transmission failures, and operational disruptions. Therefore, telecommunication infrastructure providers widely employ generator sets (gensets) as backup power sources to ensure uninterrupted operation during main power failures [1], [2]. In Indonesia, where telecommunication facilities are often located in remote or critical service areas, genset reliability becomes a key operational requirement.

Fuel availability is one of the most critical factors affecting genset performance. Inadequate fuel monitoring may lead to unexpected shutdowns, inefficient maintenance scheduling, and increased operational risks. Conventional fuel level measurement methods are often performed manually using dipsticks or visual inspection, which are prone to human error, limited accuracy, and safety concerns, especially in low-visibility conditions [3], [4]. Consequently, an automated and accurate fuel monitoring system is essential to support reliable genset operation.

In addition to fuel level, genset runhours and output power must be continuously monitored. Runhour data are crucial for determining preventive maintenance schedules, while power monitoring ensures that the genset operates within safe load limits to prevent premature equipment failure [5], [6]. Studies have shown that excessive loading and improper runtime management significantly reduce genset lifespan and increase operational costs [7].

The Internet of Things (IoT) has emerged as an effective solution for real-time monitoring and control of industrial equipment. IoT-based systems enable seamless integration of sensors, microcontrollers, communication networks, and cloud platforms to provide remote access, data visualization, and automated control [8], [9]. Recent research demonstrates that IoT-based monitoring improves system reliability, operational efficiency, and maintenance decision-making in power and energy systems [10], [11].

Several previous studies have explored IoT-based genset monitoring systems focusing on fuel level measurement, runtime tracking, and power monitoring [12]–[14]. However, limitations remain in terms of measurement accuracy for horizontal tanks, limited integration between fuel, power, and environmental parameters, and lack of automated environmental control within the genset room [15], [16].

This research aims to design and implement an IoT-based genset monitoring system that integrates fuel level measurement, runhour and power monitoring, and genset room temperature control. The proposed system utilizes an ultrasonic fuel sensor, power measurement sensor, temperature sensor, and ESP32 microcontroller to provide real-time monitoring and control through a web-based interface. The system is evaluated through experimental testing to assess accuracy, reliability, and operational effectiveness.

II. METHOD

A. System Design

This study adopts a Research and Development (R&D) approach aimed at designing, implementing, and testing an IoT-based monitoring and control system for genset operation. The R&D method is widely used in engineering research to develop functional prototypes and evaluate their performance under real operating conditions [17]. The research stages

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include system design, hardware and software implementation, system integration, and experimental testing. The type of research to be carried out is Research and Development (R&D), which is a method of research and building a tool that is a problem solver with existing methods. This research method is used to produce certain products and test the effectiveness of these products. Where later it will build a measurement tool for the level and volume of fuel in the tank and calculate the output power capacity of the power supply device then test the tool during implementation. The research process begins with research design to analysis of research results. The research design begins with a literature review, which involves a literature review of journals, articles, and dissertations related to the importance of monitoring fuel supplies for generators and maintaining generator performance in telecommunications device power supply systems and their impact on generator engine conditions, it is important to ensure the safety of maintenance personnel with the Internet of Things technology approach [9].

The application of the Internet of Things system design in helping to condition the optimal battery room will be achieved by meeting the needs of the system. A literature review is carried out to be able to produce a tool system that is able to overcome existing problems. So as to be able to define relevant parameters and identify important data in the research system.

The system will be depicted on a block diagram that explains the work process:

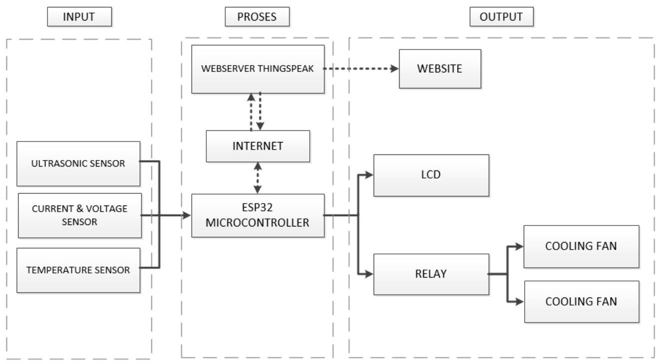

Figure 1. System Block Diagram

In the picture above, each sensor will obtain the data needed. Where, the ultrasonic sensor will detect the volume of fuel in the tank and also the current sensor measures the power usage of the generator when it is on, then the data becomes input for the microcontroller to be sent to the server using the WiFi module on the ESP32 so that the data can be monitored on the user device remotely via the internet. There is an LCD Display to display the monitoring results directly and a fan to keep the room conditions not too hot.

The system design is used to optimize the performance of a large-capacity backup power supply device owned by PT Telkom Indonesia Malang. This tool system uses the A02YYUW ultrasonic sensor to determine the height of the fuel in the tank to be converted into volume, the PZEM-004T voltage current sensor as a generator power detector, the ESP32 functions as a data receiver from the sensor and sends it to the website that has been made. The website is made on the weebly platform and the data from the system is stored on thingspeak.

The system will retrieve data from the Thingspeak datastorage to be displayed on the LCD and perform processing related to the conditioning of fuel tanks, generator sets and generator rooms so that it is easy for officers to optimize maintenance activities. Its functions include visualization of system workflows, analysis and design of structures, building mutual understanding among stakeholders, identification of dependencies and relationships, problem solving, system documentation, development team communication, training, performance evaluation, and integration with programming. As an important tool in software development, flowcharts help in designing, understanding, and managing systems more effectively [10]. This flowchart provides a visual overview of how data is collected, processed, and used in an IoT project.

The system workflow will be described by representing the processes that occur in a system through a flow chart using graphical symbols, as follows:

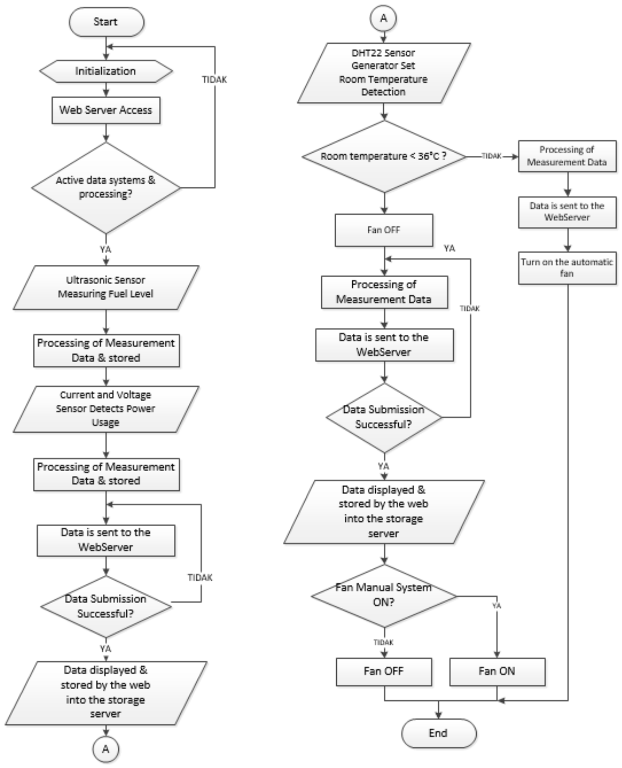

Figure 2. Flowchart System

In figure 2, it is explained about the flowchart from starting with Start. After that, the system will run and the sensor takes measurements according to its function to obtain the required data. Then, the data obtained will be managed according to the display request on the website to make it easier to read and report. The data will be automatically sent to the web server to display the value of the data on the website and this data will be received regularly every day and used for remote monitoring. If the sensor data received does not comply with the minimum and maximum limit standards, follow-up will be carried out by controlling the device, but not all conditions will take action if the value does not meet operational standards because it adjusts to needs.

B. Hardware System Design

The hardware design design of an IoT component has an integral role in the successful implementation of the project. This process involves the integration of sensors and actuators, the development of communication interfaces, the selection of components with efficient power consumption, and attention to safety aspects. Hardware flexibility and scalability, interoperability with other IoT devices, and durability in potentially harsh environments are crucial considerations. Along with that, the design must consider accurate measurement capabilities, local data processing capabilities, and efficient production costs. By approaching the overall hardware design, an IoT component can be designed to be reliable, efficient, and fit the needs and overall goals of the project.

The proposed system consists of sensing, processing, communication, and visualization layers. Fuel level is measured using a waterproof ultrasonic sensor (A02YYUW), generator power and runhours are obtained using the PZEM-004T power sensor, and genset room temperature is monitored using a DHT22 sensor. An ESP32 microcontroller processes sensor data and transmits it to a cloud platform via WiFi for storage and visualization [9], [10].

Data are displayed locally through an LCD module and remotely via a web-based dashboard. A relay-controlled exhaust fan is integrated to maintain genset room temperature within safe operating limits. This architecture enables real-time monitoring and automated control to improve genset performance and reliability [11], [18].

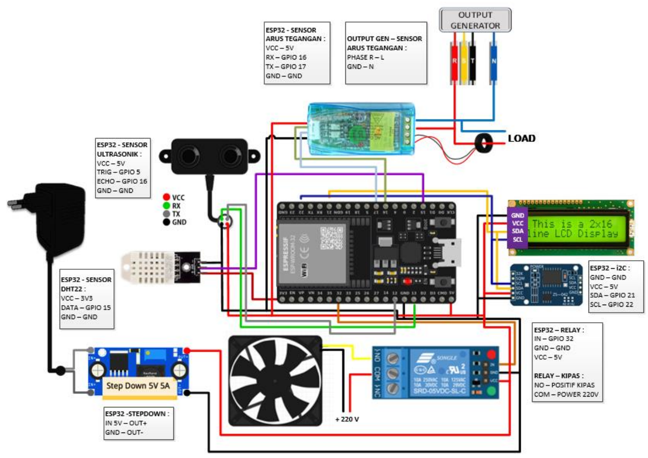

Figure 3. Hardware System Design

TABLE I
Hardware Specification

No	Pin Sensor A02YYUW	Pin ESP32
1	VCC	Vin (5v)
2	TRIG	5
3	ECHO	16
4	GND	GND
No	**Pin Sensor PZEM-004T**	**Pin ESP32**
1	VCC	Vin (5v)
2	RX	16
3	TX	17
4	GND	GND
No	**Pin Sensor DHT22**	**Pin ESP32**
1	VCC	Vin (5v)
2	OUT	15
3	GND	GND
No	**Pin Relay**	**Pin ESP32**
1	VCC	Vin (5v)
2	IN	32
3	GND	GND
No	**Pin I2C LCD**	**Pin ESP32**
1	VCC	Vin (5v)
2	SDA	21
3	SCL	22
4	GND	GND

To support the design of hardware, an overall design system is made as shown Table I. The overall system design describes the cable ports connected to each module and other electronic components. This test starts from ultrasonic sensor readings that measure fuel levels, current and voltage sensor that measure generator power, temperature sensors to measure generator room temperature. Processing microcontrollers to transferring data from hardware to servers which then data can be requested through the website.

This series of components and sensors is designed to be a tool that has a function according to the purpose. Where, this tool will be implemented in a tank and room that becomes a testing site. The description of a tool to be implemented is shown in the mechanical design, as Figure 4.

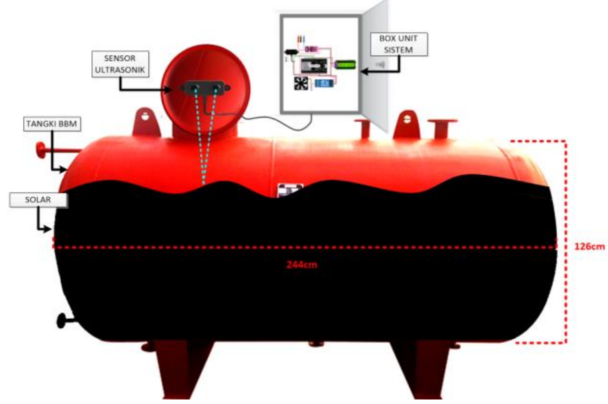

Figure 4. System Mechanical Design of Tank

Mechanical design plays a crucial role in the development of a product or system by allowing designers to design physical structures, select the right materials, optimize performance, and integrate components efficiently. The mechanical design not only ensures adequate technical functioning, but also includes aesthetics, and ease of maintenance. By planning structure, material, and functionality holistically, mechanical design aims to create products that not only perform optimally but also meet the needs and preferences of users well [8]. Fuel level is determined by measuring the distance between the ultrasonic sensor and the fuel surface. The measured fuel depth is converted into volume using the horizontal cylindrical tank volume formula. Ultrasonic sensing is chosen due to its non-contact nature, resistance to harsh environments, and suitability for industrial liquid measurement applications [15], [19],[20].

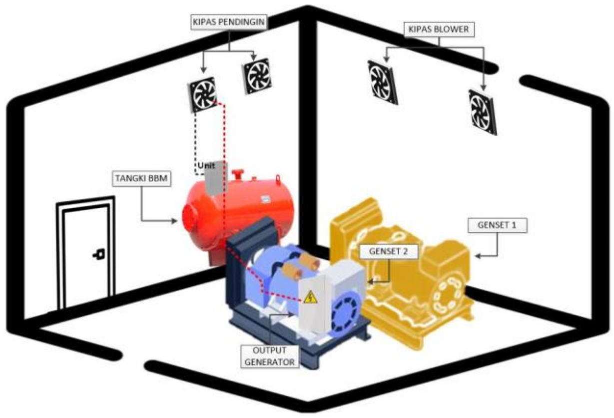

Figure 5. System Mechanical Design of Generator Room

To conduct research testing of tools that have been designed and built according to system design and mechanical design (Figure 5), a variable is needed that is measured or assessed to assess the quality, performance, or characteristics of a product or system during the testing process [11]. The testing parameters of this tool are the accuracy of the fuel level; < 3000L and ≥ 300L, the time of use of the generator engine detected based on power; < 90 minutes per day and < 40 hours per month, the suitability of the generator output power measurement with the website; < 500 kVA, according to the main power supply meter < 80% × 690 kVA and the temperature controlled to maintain engine temperature conditions; 28- 36 ℃.

III. RESULTS AND DISCUSSION

A. System Design Results

The sensor circuit design is placed in a protective box, to keep the device system connection properly installed.

In the Figure 6 and 7 of the hardware implementation results with the panel box above, it consists of an adapter that functions to provide power to various components including the a02yyuw sensor to measure the fuel level, the pzem-004t sensor to measure the generator power, the dht22 sensor to measure the generator room temperature, the lcd module to display the measurement results, esp32 as a microcontroller, lan cable to connect the ultrasonic sensor to the circuit server.

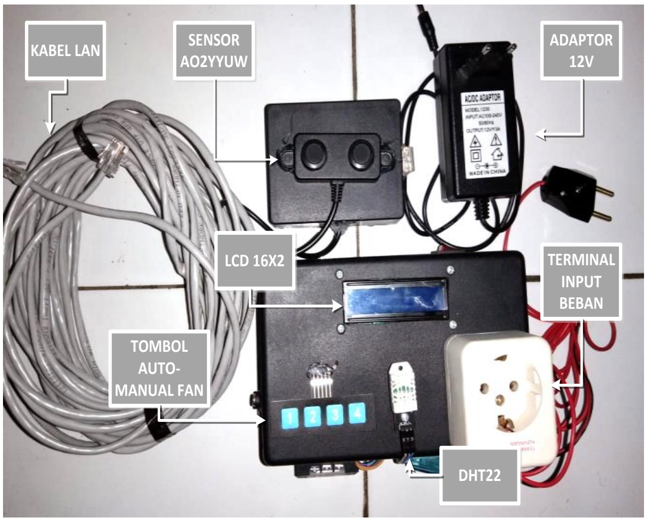

Figure 6. Hardware Implementation

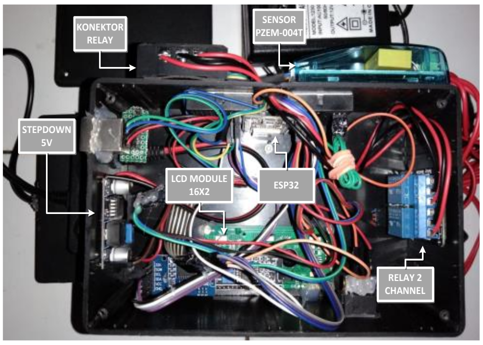

Figure 7. Circuit in panel box

There are 5V stepdown to reduce the voltage to 5 volts to adjust the needs of the components, relay as a switch to control the fan using the intermediate connector, then the keypad as an auto - manual fan button where button 1 is for auto on mode, button 2 is for auto off mode, button 3 is for manual on mode, and button 4 is for manual off mode.

Figure 8. Sensor implementation on tank

The sensor placed on the tank lid is an A02YYUW ultrasonic sensor that functions to measure the height of the fuel in the tank so that the volume or fuel content can be known, as shown in Fig. 8.

Figure 9. Implementation of hardware box in generator room

The hardware box containing the sensors and components (Figure 9) is placed in the generator room because there is a voltage sensor that must be connected to the generator and a temperature sensor that needs to detect room conditions, as well as a relay switch that controls the cooling fan.

B. *Test Results of Fuel Level Detection System*

System testing of the thesis tool is a critical stage that involves a series of steps to ensure the quality and performance of the tool. This includes functionality testing to verify that each feature works according to specifications, reliability testing to identify and correct potential errors, and performance testing to evaluate the tool's ability to handle the anticipated workload.

The results of the fuel level detection test are shown in the following figure 10 and 11 and table II.

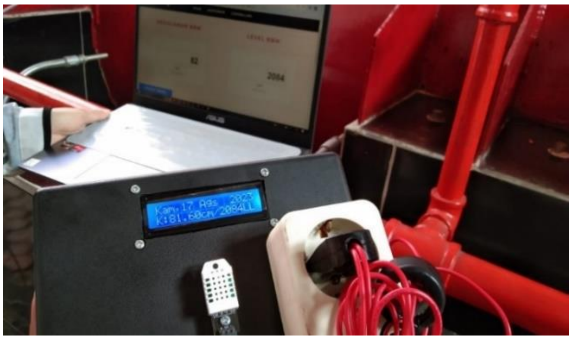

Figure 10. Fuel Level Detection Results on Hardware Box

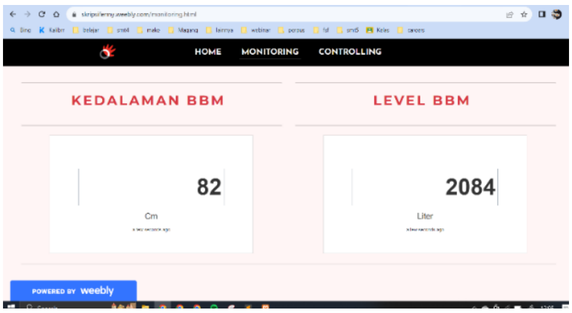

Figure 11. Fuel Level Detection Results on Website

In the picture of the test results above, the depth value on the hardware box is 81.60cm with a volume of 2084 liters while on the website the depth value is 82cm with a volume of 2084 liters. This test is applied to a horizontal cylindrical tank with a capacity of 3000 liters for fuel level detection using an ultrasonic sensor (A02YYUW) that detects the surface of the fuel with the results of reading the depth of the liquid in cm then and converted to volume in liters.

TABLE II.
OVERALL TESTING RESULTS OF FUEL LEVEL DETECTION

No.	Time	Box Hardware		Website	
		Level (cm)	Volume (L)	Level (cm)	Volume (L)
1.	17/08 – 08.11	81.60	2084	82	2084
2.	17/08 – 09.05	82.00	2096	82	2096
3.	17/08 – 10.08	82.10	2099	82	2099
4.	17/08 – 10.55	81.60	2084	82	2084
5.	17/08 – 11.48	81.70	2087	82	2087
6.	17/08 – 12.50	82.10	2099	82	2099
7.	17/08 – 13.45	82.20	2102	82	2102
8.	17/08 – 14.50	81.70	2087	82	2087
9.	17/08 – 15.53	81.60	2084	82	2084
10.	17/08 – 16.47	82.00	2096	82	2096

Based on the tests that have been done, it can be seen in table that the depth value on the highest tool is detected 82.20cm and the smallest is 81.60cm while on the web display all depth values are rounded to 82cm so that the difference in depth value between the tool and the web display is at most 0.4cm. Changes in fuel level values obtained during tool system testing are shown in the Fig 12.

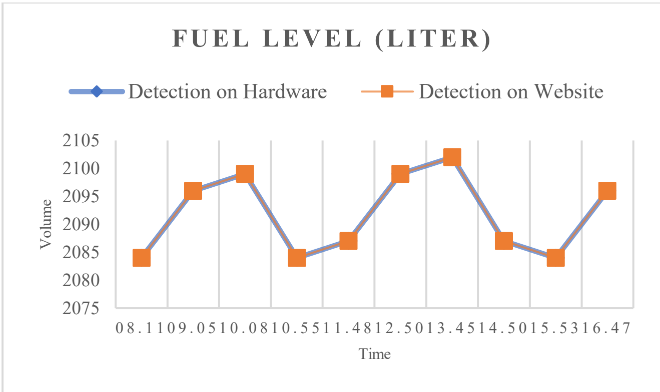

Figure 12. Fuel Level Detection Test Result Graph

The tank volume value displayed on the LCD and website is obtained from the calculation of tank volume using the depth value as a reference. The equation of the horizontal tank volume formula is as follows:

$$V = L\left[r^2 cos^{-1}\left(\frac{r-h}{r}\right) - (r-h)\sqrt{2rh - h^2}\right] \quad (1)$$

Where,

L = Tank length;

r = Tank radius;

h = Depth of fuel liquid.

From Equation 1, a horizontal tank volume calculation is carried out to determine the accuracy of the result value using a program with manual calculations. The following is the result of the calculation using the horizontal tank volume formula:

With a value of L = 244 cm; r = 63 cm

- Fuel Depth 81.60 cm

$$V =$$

$$= 244\left[63^2 cos^{-1}\left(\frac{63-81.6}{63}\right) - (63-81.6)\sqrt{2\times 63\times 81.6 - 81.6^2}\right]$$

$$= 244 \times 3969\ cos^{-1}\left(\frac{-18.6}{63}\right) - 244\ \times (-18.6) \times 60.19169378$$

$$= 968436\ cos^{-1}\left(\frac{-18.6}{63}\right) + 4538.4\ \times 60.19169378$$

$$= 2084634.52793\ cm^3$$

$$= 2084\ \text{Liter} \quad (2)$$

According to the results of these calculations (Equation 2), the exact same volume value is obtained as displayed on the LCD and website display so that it can be said to be accurate but depends on the value of the depth of fuel detected. This result is proof that measuring or detecting the volume contents of tanks with ultrasonic sensors can be obtained accurately using manual calculations of formulas as comparison material.

From the fuel oil level detection test on the tank, it can be seen that the ultrasonic sensor A02YYUW provides an accurate value in detecting the surface of the liquid and its range is also capable of detecting up to 450 cm making it appropriate to measure the depth of large-capacity tanks. In testing the fuel oil level, the value displayed on the tool is a depth of about 81 – 82.2 cm and a volume of about 2084 – 2102 liters according to the contents of the tank, where this depth value is a reference to obtain a volume value using the horizontal tank volume formula and has been proven to be the same value as manual calculations. With the detection of this fuel oil level, to monitor the fuel inventory of the generator can be monitored remotely to be more efficient in maintenance work.

C. *Test results of Runhours and Generator Power*

Testing runhours and generator set power have a major role in ensuring optimal performance and system reliability. These two tests also play an important role in monitoring generator set health, detecting potential problems, and ensuring emergency response readiness in situations of sudden power outages. The results of runhours and generator power tests are shown in the following Fig. 13 and 14.

Figure 13. Power Measurement Results on Hardware Box

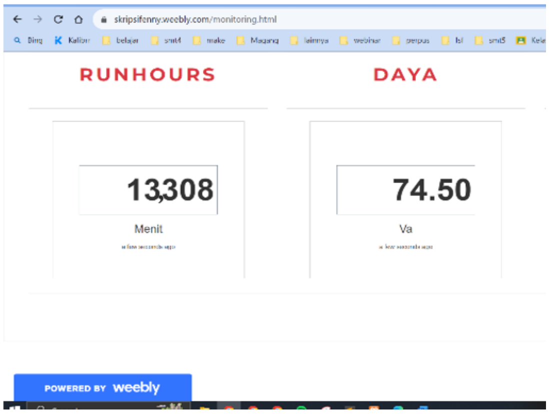

Figure 14. Runhours and Power Test Results on Website

In testing the detection of runhours and output power on the generator set, an insignificant value is obtained between the tool and the website, namely the difference or difference due to the value of current flow and voltage that changes depending on load consumption. The power value obtained has a difference of 0.1 – 0.3 vA. It can be seen in the table II.

TABLE III.
OVERALL TESTING RESULTS OF RUNHOURS AND GENERATOR POWER

No.	Condition	Hardware Power (vA)	Website *Runhours* (menit)	Website Power (vA)
1.	Generator Set Turns On	88.50	0	88.50
2.		45.30	0	45.30
3.		78.70	0	78.70
4.		56.20	0	56.30
5.		94.50	0	94.50
1.	After it turns off, then turns it back on again	52.50	13.308	52.50
2.		74.50	13.308	74.50
3.		33.60	13.308	33.50
4.		41.00	13.308	40.80
5.		58.40	13.308	58.70

Based on the tests, it can be seen in the table above that the value of power obtained on the tool and website there is a difference, namely the difference in values of about 0.1 – 0.3 vA for power, because the value of current flow and voltage obtained depends on the load. It is shown about the measurement when the generator turns on with after a pause temporarily turned off to obtain the *runhours* value because the value can be seen when an engine or load from the device is turned off, then the table states that the generator has been on for about 13 minutes during testing.

Generator set or generator is a device that can produce electricity consisting of a combination of altenator and engine that functions as a power generation tool. The working principle consists of an engine or motor that uses diesel to power it [9]. Generators in telecommunications companies function as a backup power source to maintain the continuity of communication network operations. In the event of a power outage or emergency, generators are activated to ensure that telecommunications equipment, such as metro devices and signal systems, keeping telecommunications connectivity and services available.

Generators also help in managing load peaks, increase resistance to power interruptions, and conduct regular trials to ensure reliable power availability in the event of an emergency or power outage. As part of the operational continuity strategy, the role of generators is very important in supporting the reliability of telecommunications services [12].

Testing runhours helps determine how long a generator set can operate continuously before requiring regular maintenance or maintenance, optimizes maintenance schedules, and measures fuel efficiency. Meanwhile, power testing helps verify that generator sets are producing power at their announced capacity and can cope with varying workloads. Thus, testing runhours and generator sets is a proactive measure to maintain optimal performance, improve operational efficiency, and minimize the risk of system failure (Figure 15).

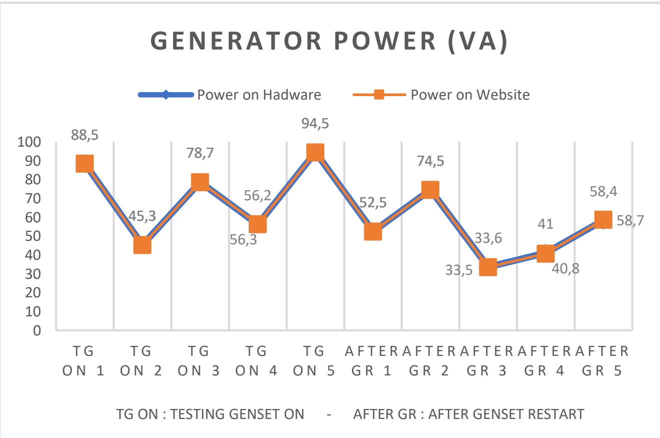

Figure 15. Generator Power Test Results Graph

D. Test Results of Temperature Detection for Fan Control

Controlling generator room temperature conditions is essential in maintaining optimal performance and system reliability. In the test results, this tool is applied to the exhaust fan in the generator room to maintain room conditions as a maintenance of the generator engine using a temperature sensor (DHT22) so that the performance of the generator engine is better. The results of temperature testing and fan control in the generator room are addressed in the Fig. 16, 17 and 18.

Figure 16. Temperature Conditions on Hardware Box and Cooling Fan Auto Turn On

Figure 17. Temperature Conditions on Website and Cooling Fan Auto Turn On

Based on the tests that have been carried out, it can be seen in the table above that the temperature value depends on the condition of the room accordingly, but in accordance with the maintenance standards the room condition limit is 36 °C to provide action to turn on the exhaust fan if the temperature conditions increase above it in order to maintain room circulation and avoid the engine overheating.

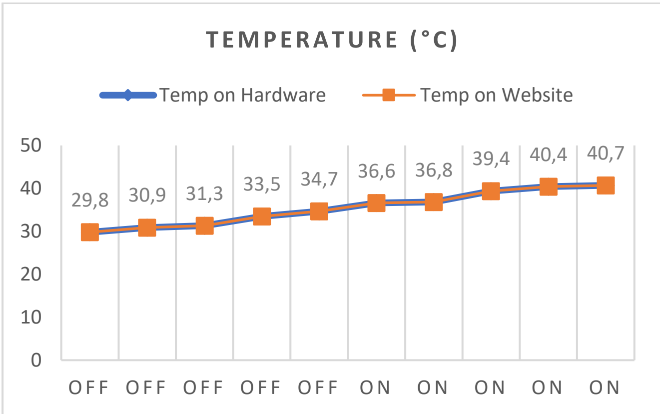

Figure 18. Genset Room Temperature Test Results Graph

From the temperature detection test of the genset room which is airtight and stuffy, the temperature value becomes a parameter to control the exhaust fan. The temperature value in the generator room is normally around 28 - 35 °C, but when the generator engine is turned on for a few minutes in the room the temperature will rise so it needs control to maintain room temperature with a command to turn on the exhaust fan when the temperature is detected above 36 °C automatically and manually. On the wall that on each side is given a cushion to subside the sound of the generator engine causes the room temperature to get higher and stuffy so that it can cause damage to the engine if it happens continuously such as the risk of overheating, component damage, decreased performance, etc.

Temperature control helps prevent overheating that can damage vital components such as engines and generators, keeps operational temperatures within recommended limits for maximum efficiency, and protects electronic components and sensors from extreme temperatures that can cause failure. In addition, temperature control also plays a role in maintaining appropriate humidity conditions to prevent corrosion and support cooling system operation. By maintaining the ambient temperature within a safe range, the generator set has a better chance of operating efficiently, increasing its lifespan and ensuring overall system availability.

IV. CONCLUSION

Based on the formulation of the problem that has been made, planning and testing and the results of research using the a02yyuw sensor to measure fuel levels, pzem-004t sensor to measure generator power, dht22 sensor to measure generator room temperature, the following conclusions can be drawn. In the fuel level test, value displayed on hardware is a depth of about 81 – 82.2cm and a fuel volume of around 2084 – 2102 liters according to the contents of the tank. This result is proof that measuring or detecting the volume contents of tanks with ultrasonic sensors can be obtained accurately using manual calculations of formulas as comparison material. For testing the detection of runhours and output power on the generator, it can be seen that the value of power obtained on the tool and website there is a difference, namely the difference in values of about 0.1 – 0.3 vA for power, the cause is because the value of current flow and voltage obtained depends on the load within 13 minutes runhours during testing. To obtain the runhours value can be seen when a machine or load from the device is turned off. From the generator room temperature detection test, it can be seen that the temperature value of 29.80°C – 40.70°C is a parameter to control the exhaust fan, which is in accordance with the maintenance standard the room condition limit is 36°C to provide the action of turning on the exhaust fan when temperature conditions increase to maintain room circulation and avoid the engine overheating.

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