

Design and Construction of an Arduino-Based Main Engine Overheating Detection Prototype

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Abstract.

Overheating in the ship's main engine, often caused by suboptimal cooling and lubrication systems, poses a high risk to performance and safety. This study aims to design and build an Arduino-based detector prototype. Using a research and development (R&D) method with an experimental approach, the population of b diesel at the Surabaya Maritime Polytechnic, a purposive sample of one Mitsubishi S6B3-MPTA unit. Instruments include Arduino Uno, thermocouple and SW200D sensors, LCD, buzzer, and Wemos D1 Mini integrated with Blynk; quantitative descriptive data analysis through Arduino IDE, comparing readings with a thermogun and connectivity tests. The results show high accuracy of temperature detection (dynamic trend 30.75-34°C), vibration (2-7 mm/s), and IoT range up to 185 m non-obstacle. In conclusion, the prototype effectively provides real-time warnings, improving preventive maintenance.

Keywords: Arduino; Blynk; Main Engine; Overheating Detection and Thermocouple.

I. INTRODUCTION

Indonesia is one of the largest archipelagic countries, with oceans connecting the islands. The shipping sector plays a significant role in the economic progress of Indonesia and the world. Numerous shipping companies, with a wide variety of vessel types, provide transportation services, each powered by a main engine and auxiliary engines (Virgiantara et al., 2023). Ships are the most effective mode of maritime transportation for transporting large numbers of passengers and cargo in a highly efficient manner. However, ship operations are highly dependent on the performance of the main engine, which often overheats due to fuel combustion, which generates excessive heat if the cooling and lubrication systems are not optimal. This overheating phenomenon can significantly reduce engine performance and potentially cause serious damage if not detected early. On vessels like the MT. Gas Maluku or KM. God Bless 08, overheating has been recorded due to pipe blockages or corrosion in the heat exchanger, which disrupts the flow of cooling water. The cooling system is an element that supports the smooth operation of the ship's main propulsion engine. Consequently, if the main engine cooling system is not perfect, it can affect the important components of the main propulsion engine. If this happens, it will cause fatal impacts and hamper ship operations (Daffa Ali Gunarinl & Abdul Hadi Eko Saputra, 2023). The main problems arise from the suboptimal main engine cooling system, such as strainer blockage, pump impeller wear, or dirt accumulation in the sea chest, which causes a sudden increase in temperature.

This not only causes decreased fuel efficiency and the risk of blackouts, but also endangers navigational safety and forces engine speed reduction. The lack of a real-time monitoring system exacerbates the situation, as engine crews are often late in detecting temperature increases or abnormal vibrations that indicate overheating. Previous research, such as fuzzy logic vehicle engine temperature monitoring (Dongaran et al., 2020) or Arduino-based temperature sensor simulations (Pratama & Permana, 2021), has not fully addressed the extreme conditions of ships. Manual detection that relies on visual observation or conventional indicators is often inaccurate, especially during long voyages, thus risking permanent damage such as exhaust valve rupture. This research aims to design and build a prototype of an Arduino Uno-based main engine overheating detector with a thermocouple sensor for temperature, SW200D for vibration, buzzer and LCD as indicators, for early detection and providing automatic warnings. The urgency of the research lies in preventing ship downtime, saving maintenance costs, and improving operational safety amidst the rise

in overheating incidents on Indonesian ship main engines. The novelty lies in the integration of simple Arduino-based IoT monitoring tailored for ship main engines, surpassing previous research such as server room monitoring (Hadi & Jumadri, 2020) with the addition of vibration detection and the Blynk application for remote access.

II. METHODS

This research uses a research and development (R&D) method with an experimental approach, which focuses on the design and construction of an Arduino-based main engine overheating detector prototype to test the causal relationship between temperature and vibration sensor variables and early warning. This type of research is applied, involving data collection through systematic observation and experiments such as static (individual components) and dynamic (on the Mitsubishi S6B3-MPTA diesel engine) testing, as explained by Sugiyono (2021) that R&D is effective for developing prototype products that can be empirically tested for validity. This approach is aligned with the ADDIE model (analysis, design, development, implementation, evaluation) to ensure the prototype functions optimally in a maritime context. The research instruments include hardware such as an Arduino Uno as the main microcontroller, a thermocouple sensor for temperature measurement, an SW200D sensor for vibration detection, a 16x2 LCD as a display, a buzzer for alarms, and a Wemos D1 Mini integrated with Blynk for remote IoT monitoring. Data analysis techniques are descriptive quantitative with measurement comparisons (e.g., thermocouple vs. thermogun), connection distance testing (non-obstacle up to 185 m, obstacle up to 135 m), and temperature trend graphs (30.75-34°C during engine operation), processed using the Arduino IDE in C language for accuracy verification.

Sudaryono et al. (2021) emphasize that the development of such instruments must be validated through repeated experimental reliability tests, while Emzir (2021) supports descriptive analysis to interpret sensor data objectively. The study population was the main diesel engines of ships in the Surabaya Maritime Polytechnic, specifically the Mitsubishi S6B3-MPTA model (503 HP, 1500 RPM, 6-cylinder) as a representation of real operational conditions. Samples were taken purposively with one unit of the engine for dynamic testing, as it covers typical overheating heat and vibration characteristics, as stated by Sugiyono (2021) who stated that purposive sampling is ideal for prototype development with limited access. This approach ensures relevant data without broad generalizations, as recommended by Creswell & Creswell (2023) for single-case experimental designs. The research procedure begins with system design (block diagram and flowchart), hardware assembly (sensor wiring to Arduino), software programming (Arduino IDE), static testing (individual component functions), dynamic testing (real-time monitoring of the engine), and data analysis and evaluation of the prototype's effectiveness in preventing overheating. Each stage is sequentially documented for replicability, with iterations based on test results, in line with Sugiyono's (2021) R&D model, which emphasizes a phased development cycle. Emzir (2021) and Sudaryono (2021) reinforce this procedure by emphasizing systematic observation and instrument validation for credible conclusions.

III. RESULT AND DISCUSSION

Research Location

Prototype testing was conducted on the Surabaya Maritime Polytechnic campus, utilizing a diesel engine with the following specifications.

Table 1. Diesel Engine Specifications

Model	Mitsubishi S6B3-MPTA
Engine Type	4-Stroke, 6-Cylinder Water-Cooled
Maximum Power	503HP
Work Cycle	1500RPM
Fuel System	<i>Direct Injection</i>
Bore x Stroke	135 mm x 170 mm
Production Year	1990

Source: Personal Document

Table 1 shows a diesel engine with selection based on its stable characteristics for experimental testing needs.

Hardware Design Results

This circuit is one of the important components in the design of the "Prototype Design and Construction of an Arduino-Based Main Engine Overheating Detection Tool." The tools that will be used in this research include:

1. Arduino UNO
2. Sensor *Thermocouple*
3. SW200D Sensor
4. LCD
5. Wemos
6. *Smartphone*
7. *Buzzer*

This circuit requires knowledge of how these devices (sensors) work. This knowledge includes sensor performance, communication between the Arduino UNO and the sensors, and how they connect to the system. *smartphone*, in figure 1 below is the design *hardware* from *prototype* the said.



Fig 1. Hardware Series

Source: Researcher's document

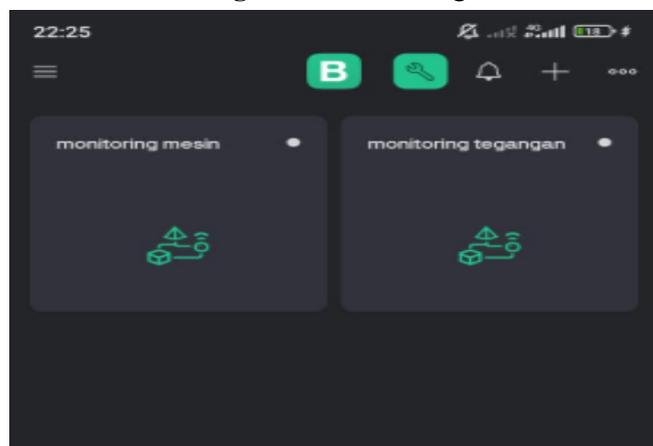
Software Design Results (Software)

The results of software creation are an implementation of hardware design, taking this into account, it is also very important to make the tool work optimally. Below are the results of the software design "Design and Build" *Prototype Occurrence Detector Main Engine Overheating Arduino based*".

1. Blynk On *smartphone*

This page is the first page that will appear when you open the Blynk application. *smartphone*. This page contains a graph of the situation in the room and the data that is recorded. *record* in the application.

Fig 2. Software Design



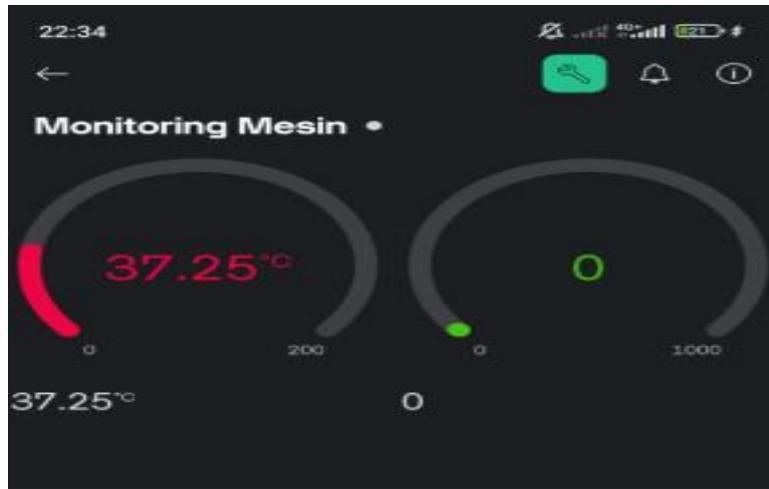
Source: Research Documentation

Figure 2 shows the Blynk app's display, customized for the device's use. This simple display can be further expanded if you want to add multiple sensors.

2. Graphic Results and Monitoring Data in Blynk

This page contains data and graphs from the results. *monitoring* from the performance of the sensors used. This page contains information, including information *monitoring* temperature and vibration. In the Blynk application display, for the results data *monitoring* The temperature starts from 0°C to 200°C. while for the vibration sensor display starting from 0 to 1000.

Fig 3. Page View *Monitoring*



Source: Research Document

In figure 3 with page view *monitoring* As shown in the image, it's very easy to see improvements. These results will make preventive maintenance on the machine much quicker.

Discussion of Research Implementation

In this stage, we will explain the various aspects that were planned and designed in the previous discussion. This explanation aims to demonstrate that the design has performed as expected by understanding the assembly process. These stages include:

1. Discussion of Tool Component Implementation

A. Microcontroller (Arduino Uno)

This device is required and used for data processing and commanding the sensors. Communication between the Arduino Uno and the sensors is achieved through the Arduino IDE. The design directly utilizes jumper cables to connect the Arduino to the sensors, providing commands and power to the sensors.

B. Thermocouple Sensor

This thermocouple sensor is one of the sensors used in this research. This sensor functions to detect the temperature of the main engine.

C. SW200D Sensor

The SW200D sensor is one of the sensors used in this research. This sensor detects vibrations in an object. This sensor is passive, meaning it only receives vibrations without producing them itself.

D. 16x2 LCD

The 16x2 12C LCD is the display device used in this research. Using a 16x2 LCD, we can view and monitor sensor conditions and program processes running on the device. 12C is a two-way serial communication standard that uses a dedicated channel to receive data.

E. Wemos D1 mini

The Wemos D1 mini is one of the components used in this research. Its function is to connect the microcontroller device by receiving Wi-Fi on a smartphone and using the Blynk application.

F. Giving Commands in the Arduino IDE Application

The command-issuing process involves several steps, including creating the command in the form of coding. During the command-issuing process, data is collected from the sensor and connected to Blynk.

In Figure 6. Evaluation of the 16x2 type 12C LCD, it can be concluded that the LCD used in this test functions optimally because it can display the command display given on the LCD from the Arduino IDE.

C. Buzzer Testing

This buzzer test is performed to ensure that the device is properly assembled. The buzzer is tested by connecting the buzzer to the microcontroller via pin 13 and GND. After connecting, the buzzer is then commanded to function.



Fig 7. Buzzer Testing

Source: Researcher Documentation

Figure 7 shows that the buzzer sensor is functioning optimally after connecting. This is because the buzzer actively alarms when the sensor detects a temperature above 90°C.

D. SW200D Sensor Testing

The SW200D sensor was tested to ensure proper function during assembly. The SW200D sensor was tested by connecting the sensor to the microcontroller via the VIN, GND, and 2 pins. Programming was then performed using Arduino software.

Fig 8. SW200D Sensor Testing



Source: Researcher Documentation

Figure 8 shows that the SW200D sensor is functioning optimally, as the sensor data is displayed on the LCD. The test was carried out by shaking the sensor with a finger.

E. Thermocouple Sensor Testing

The way to test the thermocouple sensor is to connect the sensor to the MAX6675 driver, then connect the driver to the Arduino Uno microcontroller on the GND, VIN, -10, -11, and 12 pins.



Fig 9. Themocouple Sensor Testing

Source: Researcher Documentation

In Figure 9, this test uses a thermocouple sensor that is tested using a soldering iron to measure the temperature and is successful, as evidenced by the sensor value displayed on the LCD. Based on the test results, the thermocouple sensor is able to detect temperature changes well and provides stable output values within the specified measurement range.



Fig 3. Comparison of Thermocouple Sensor Testing

Source: Researcher Document

In figure 10 is a way of comparing using *thermogun*. By making a comparison between sensor *thermogun* 30 times, indicating that the sensor's performance is optimal or in accordance with the measured temperature. The test results are presented in the following table.

Table 2. Comparison of Thermocouple with Thermogun

No.	Initial Value (C°)		Time (Seconds)	Final grade (C°)	
	<i>Thermo couple</i>	<i>Thermo gun</i>		<i>Thermo couple</i>	<i>Therm ogun</i>
1	34.75	33.7	5 seconds	36.50	35.6
2	34.50	32.4		36.75	35.4
3	34	33.1		37	36.3
4	35.25	33.3		37.25	36.6
5	34.75	34.5		36.50	37.2
6	34.50	33.1		36.50	36.4
7	34.25	32.9	10 seconds	39.75	38.4
8	34	33.4		39.50	39.2
9	33.75	33.5		38.25	39.5
10	33	33.2		38	39.6
11	34.75	32.5		39	38.6
12	34.50	32.8		39.25	39.1
13	34.25	33.5	15 seconds	41.75	40.5
14	34.75	33.9		42	41.7
15	34.50	32.1		42.25	41.8
16	35.50	32.9		43	42.7
17	34.75	33.1		42.75	40.4
18	35.25	32.8		43.50	42.4
19	34.25	32.7	20 seconds	45.50	44.8
20	34	32.4		45	44.1
21	33.75	33.1		44.50	43.6
22	33	33.3		44.25	43.8
23	34.75	34.5		46	44.5
24	34.50	33.1		45.75	43.6
25	34.25	32.9	25 seconds	48.50	47.3
26	34.75	33.4		49.25	48.2
27	34.50	33.5		48.75	47.8
28	35.50	33.2		50.50	49.7
29	34.75	32.5		49.50	48.9
30	35.25	32.8		50.25	49.8

Source: Researcher Document

Table 2 shows the thermocouple sensor test compared to the thermogun. The following graph provides information on each time point in the experiment. Using the graph makes it easier to see the data from the thermocouple sensor and the thermogun's reading range in degrees Celsius.

Fig 11. 5-second Thermocouple Test

Source: Researcher Document

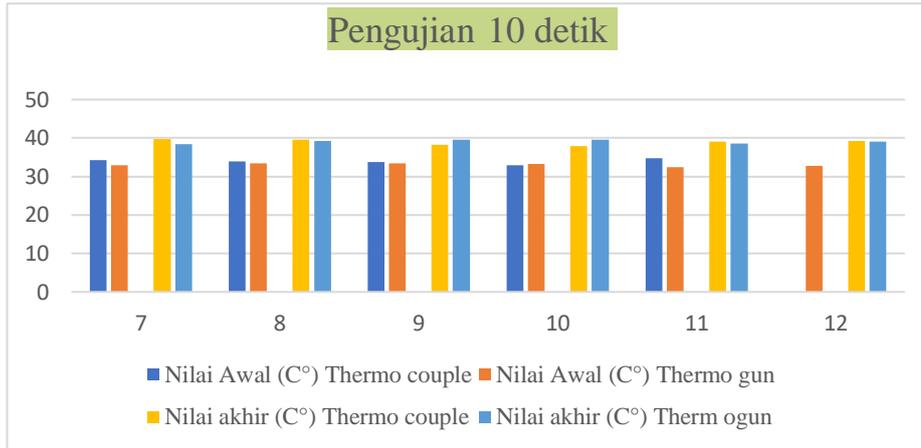


Fig 12. 10-second Thermocouple Test

Source: Researcher Document

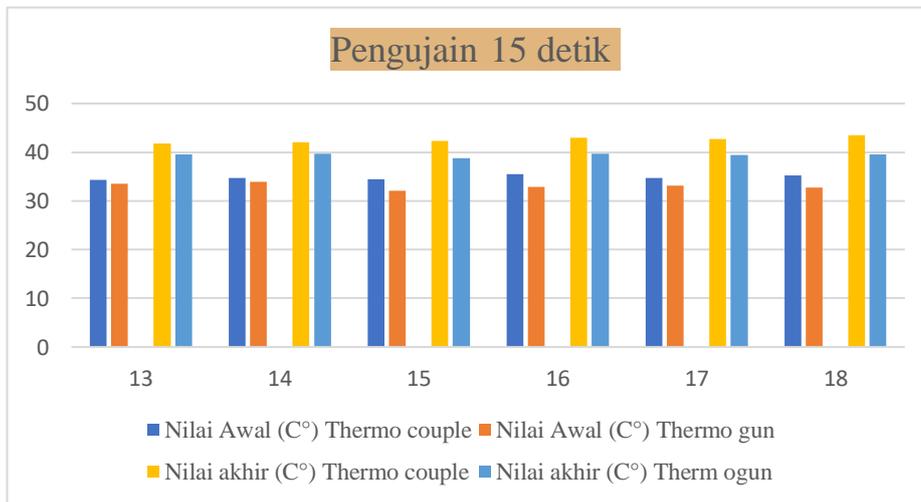


Fig 13. 15-second Thermocouple Test

Source: Researcher Document

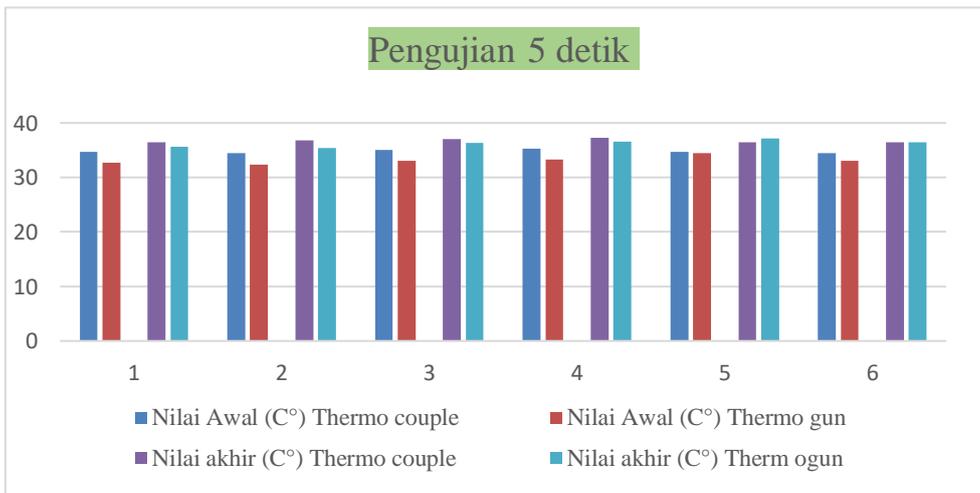


Fig 14. 20-second Themocouple Test

Source: Researcher Document

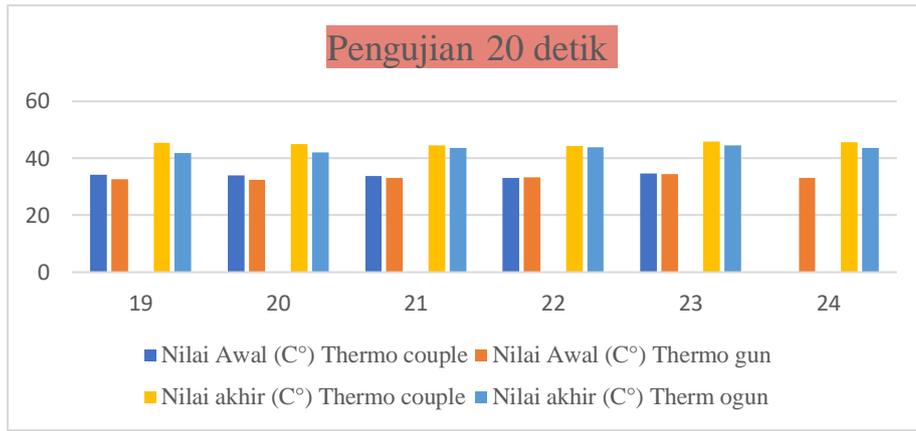
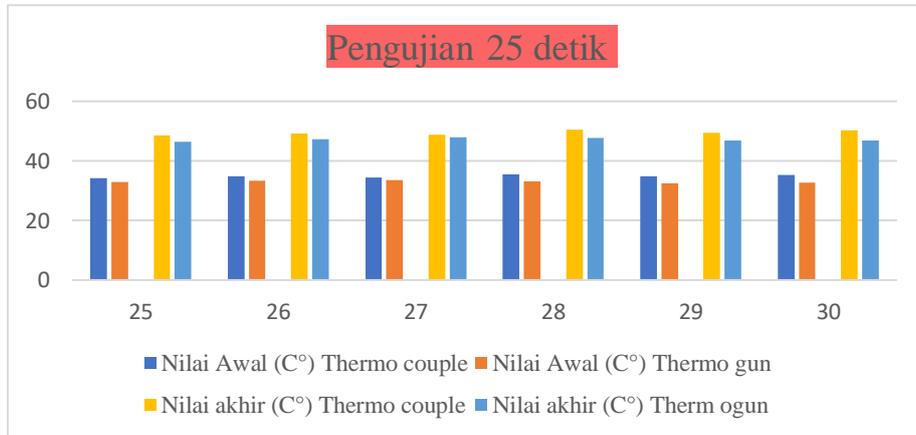


Fig 15. 25-second Themocouple Test

Source: Researcher Document



F. Data Transmission Distance Testing

Testing was conducted in two phases to assess the system's connectivity capabilities. In the first phase, testing was conducted in an outdoor area without any separation or obstacles between the two devices (non-obstacle). The second phase was carried out by adding a physical obstacle in the form of a wall, where the devices were placed in a closed room (obstacle). At each stage, the testing process measured the stability of the connection from the closest distance to the maximum distance where the connection between the devices would experience interference and be disconnected. The purpose of this test was to measure the performance of Wemos in receiving signals from smartphone hotspots both in unobstructed conditions and in the presence of physical obstacles. The results of this evaluation were used to ensure the reliability of the system when applied to remotely monitor the temperature and vibration of the main engine using the blynk application.

Table 3. Non-Obstacle Tool Connection Distance Test

No	Distance (m)	Information
1	25	Connected
2	50	Connected
3	75	Connected
4	100	Connected
5	125	Connected
6	150	Connected
7	175	Connected
8	185	Not Connected

Source: Researcher Document

Next, the device was tested under obstructions. During this phase, the test took place in a closed room with a brick wall, with the door closed.

Table 4. Obstacle Distance Testing

No	Distance (m)	Information
1	25	Connected
2	50	Connected
3	75	Connected
4	100	Connected
5	125	Connected
6	135	Not Connected

Source: Researcher Document

The test results in Table 3, using non-obstacle testing, show a range of 0–185 meters. The results were also influenced by the quality of the hotspot connection on the researcher's mobile phone. Table 4 shows the results of the obstacle test, which showed a range of 0–135 meters. This study also influenced the quality of the device used in the study.

2. Dynamic Testing

This dynamic testing was conducted to obtain information regarding the performance of the thermocouple and SW200D sensors, as well as to measure the effective data transmission distance. The testing was carried out by directly testing the test material, a diesel engine, in the Workshop building of the Surabaya Maritime Polytechnic.

Fig 16. Dynamic Testing

Source: Researcher Document

The dynamic test in Figure 16 has the same results as the previous static test on each component, therefore the tool test with the test material is declared feasible. This dynamic test was also designed by the researcher to determine the overall performance of the tool. Based on the results of vibration measurements using the SW200D sensor and thermocouple sensor, an average vibration speed value of 2-7 mm/s was obtained and the average temperature during the test ranged from 30.75 °C – 34 °C under main engine operating conditions. The emphasis of the results is that the tool can detect heat from the engine and can display the results on the LCD of the tool and the researcher's cellphone which has been connected to the blynk application.

Data analysis

Data analysis was conducted to evaluate the results of the activities listed in this study. This analysis aimed to determine the extent to which the activities were implemented in accordance with the planning, work procedures, and established objectives, while also assessing the effectiveness and results of the processes. This data analysis is expected to provide an objective picture of the activity's achievements as a basis for drawing conclusions. The discussion of the analysis results shows that the suitability between planning and implementation is the main factor in achieving the expected results. The implementation of activities carried out systematically and structured has a positive impact on the quality of work results. It is shown that the testing of the microcontroller used, namely Arduino Uno, can run smoothly. The use of LCD and buzzer as a communication tool on the tool by showing the results on the LCD screen and buzzer to determine the machine in an abnormal condition. The results of the data from the SW200D sensor are the level of vibration produced by the machine, therefore it can monitor vibrations in the machine. The results of the data from the thermocouple sensor show data from the heat produced so that it can monitor how many degrees C° the machine. The results of the last study, namely monitoring carried out on the blynk application,

which got results in the non-obstacle test, got results of 0-185 meters that could be connected and in the obstacle test got results of 0-135 meters. This distance test depends on the researcher's cellphone used, so the results can change if the cellphone used has a stronger hotspot range quality. Based on the overall data analysis results, it can be concluded that the testing of the tool and test materials was carried out well, considering that the tool is a prototype model. Therefore, further development of the research tool prototype is also necessary so that this prototype tool can be useful in the future.

IV. CONCLUSION

This research successfully produced a prototype of an Arduino-based main engine overheating detector that effectively detects temperature increases (higher accuracy than a thermogun, trending 30.75-34°C in dynamic testing) and vibrations through thermocouple sensors and SW200D, with buzzer warnings, LCD displays, and IoT monitoring via Blynk up to 185 m non-obstacle. The main findings show that the system functions optimally on the Mitsubishi S6B3-MPTA diesel engine, preventing premature damage through automatic alarms and remote connectivity, surpassing conventional manual approaches. The practical implications are increased ship operational safety, reduced maintenance costs, and predictive maintenance for engine crews at the Surabaya Maritime Polytechnic. However, limitations of this research include the prototype's status as it has not been fully field tested on operational vessels, its susceptibility to WiFi hotspot interference, and its reliance on a single engine model, which may result in varying accuracy under extreme maritime conditions. Suggestions for further research include the integration of additional sensors such as the LM35 for redundancy, onboard barge trials, battery power optimization for autonomous operation, and ISO 10816 validation for vibration. This development has the potential to be implemented by the national shipping industry to reduce overheating incidents.

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