Design of Sterilizer Calibration With Esp8266 Based on Internet of Things

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ABSTRACT: Increasingly advanced technology demands the development of a monitoring system on an indicator, one of which is temperature. Temperature is a quantity that indicates the degree of heat and cold of an object. Temperature is a very important indicator in research that requires the use of a stable temperature. The development of technology in the industrial era 4.0 is one of the references in making the design of the tool. One of the technologies developing in it is the Internet of Things (IoT). IoT will make it easier to monitor something because it can be accessed in real time. In this study, the development of a Sterilizer Calibration Tool has been made, with ESP8266 Based on the Internet of Things. The manufacture of the tool has been successful according to plan starting from the components used, the casing model used, and the applications created. The results of the study, the deviation of temperature measurements with a setting of 150 ℃ has an average of 0.5 ℃. For temperature measurements with a setting of 200 ℃, it has an average of 0.1 ℃. Based on the testing process according to the Medical Device Calibration Work Method No. 044-18 of 2020 concerning Testing of Sterilizers is declared suitable for use because it has a tolerance that is still permitted, namely ± 5 ℃.
KEYWORDS: Temperature, Internet of Things (IoT), ESP8266.

I. INTRODUCTION

The advancement of technology in the era of Industry 4.0 has triggered significant changes in various sectors, particularly in the field of instrumentation and automation. One of the most critical measured parameters in biomedical and industrial applications is temperature, especially in devices such as sterilizers, where precise and consistent thermal conditions are essential for achieving effective sterilization [1]. Temperature, as a physical quantity, reflects the degree of heat or coldness of an object and requires regular monitoring to ensure operational accuracy and safety [2].

Traditional sterilizer monitoring methods often rely on manual readings using mercury or alcohol-based thermometers. These conventional tools not only limit the frequency of readings but are also prone to observational errors and inefficiencies in terms of technician workload [3]. With the increasing demand for real-time data acquisition and remote accessibility, integrating modern technologies such as the Internet of Things (IoT) into monitoring systems has become a necessary innovation [4].

The Internet of Things allows devices to communicate, process, and exchange data via internet protocols without direct human involvement [5]. In the context of sterilizer calibration, IoT enables real-time data visualization and analysis, reducing the physical presence required by technicians and facilitating efficient multitasking in clinical or laboratory environments [6]. According to the Indonesian standard Work Method No. 044-18/2020, sterilizer calibration typically requires a test duration of approximately 75 minutes and relies on digital thermometers for temperature measurement [7]. However, due to the limited display capability of standard character LCDs (e.g., 20x4), visualizing temperature dynamics over time is still challenging.

Previous studies such as by Neolaka [8] demonstrated the design of a basic sterilizer calibration tool but lacked IoT features and graphical visualization. Meanwhile, modern design approaches utilizing microcontrollers like ESP32 or ESP8266, paired with waterproof temperature sensors and cloud platforms, have shown promise in remote calibration applications [9]. By embedding IoT capabilities and using TFT LCDs, graphical trends of thermal behavior can be displayed directly, offering enhanced insight into the sterilization process.

Therefore, this study aims to develop a smart sterilizer calibration tool using the ESP8266 microcontroller, integrated with an IoT-based real-time monitoring system, graphical visualization via TFT LCD, and cloud data logging features. This innovation is expected to increase the efficiency, accuracy, and practicality of the calibration process in hospital or industrial settings.

II. OVERVIEW

The need for smart, autonomous instrumentation systems has led to the development of various temperature calibration tools with microcontroller-based control systems. In a study by Neolaka [8], a sterilizer calibration tool was designed using a basic LCD module, which lacked the ability to present temperature trends in real time. The absence of IoT features made it less effective for technicians who must calibrate multiple devices under time constraints.

In contrast, Akbar et al. [9] designed an IoT-based autoclave calibration system equipped with SD card data logging and integrated DS18B20 waterproof sensors using the ESP32 microcontroller. Although this research shares the same goal of remote calibration, it differs in microcontroller type and sensor configuration.

Another study by Prayudha et al. [10] developed a thermobath calibration system using a type-K thermocouple and an Arduino Uno microcontroller. Their focus on temperature and pressure control illustrates the growing application of microcontrollers in calibration but uses different hardware compared to this study.

Azhar et al. [11] explored the use of digital temperature controllers in calibration, highlighting the relevance of controller precision in determining measurement accuracy. In similar fashion, Bojan [12] demonstrated interfacing thermocouples with ESP8266 to improve thermal data acquisition in embedded systems.

The uniqueness of this research lies in combining ESP8266 with IoT and a TFT display, allowing real-time graphical monitoring of temperature fluctuations, remote access via Wi-Fi, and efficient data processing—improving the overall performance and flexibility of the sterilizer calibration process.

III. METHODS

This study uses the Research and Development (R&D) approach to design, prototype, and test a new calibration system. The development stages include analysis, system design, implementation, and evaluation.

A. System Design

The main components include the ESP8266 NodeMCU microcontroller, type-K thermocouple sensor connected via MAX6675 module, TFT LCD screen, and IoT cloud platform (e.g., ThingSpeak) for data visualization. The tool is programmed using Arduino IDE with libraries that support sensor reading, data display, and HTTP data transmission.

B. Data Collection and Analysis

Temperature data are collected from the sterilizer chamber every 10 seconds over a 75-minute calibration window. All data points are logged into the cloud in real-time and displayed both numerically and graphically on the TFT screen. Comparative analysis is conducted with a reference digital thermometer to assess measurement accuracy. According to Widyaiswara [6], effective data analysis begins in the field during initial data acquisition to ensure that critical information is captured comprehensively.

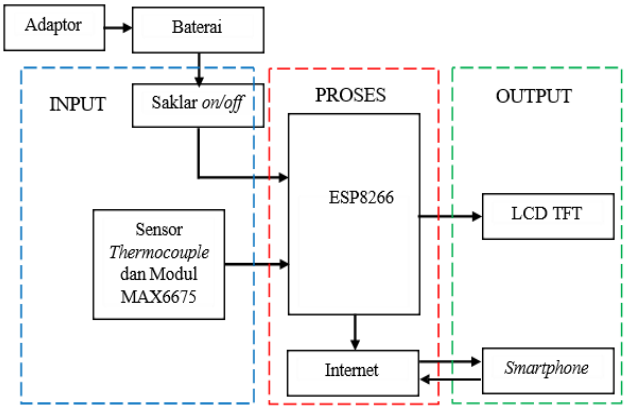

Fig 1. Block Diagram

IV. RESULTS AND DISCUSSION

A. Tool Discussion

Testing the thermocouple sensor at a temperature of 150℃. The test results are shown in the following table:

Tbl 1. Measurement Results at 150℃

Point	Reference Tool (°C)	Project Tool (°C)	Deviation (°C)	Error Factor (%)
1	150,7	150,5	0,2	0,1
2	150,7	150,5	0,2	0,1
3	150,8	150,5	0,3	0,2
4	150,8	150,45	0,3	0,2
5	150,7	150,5	0,2	0,1
6	150,6	149,5	0,5	0,3
7	150	149,55	0,5	0,3
8	150,1	149,5	0,5	0,3
9	150	149,5	0,5	0,3
10	150,2	149,55	0,6	0,4
11	150	149,5	0,5	0,3
12	150,2	149,55	0,6	0,4
13	150,1	149,5	0,6	0,4
14	150,2	149,55	0,6	0,4
15	150,2	149,55	0,6	0,4
Average	150,4	149,85	0,4	0,3

The following is a comparison graph of the 150 ℃ temperature test, shown in the following figure:

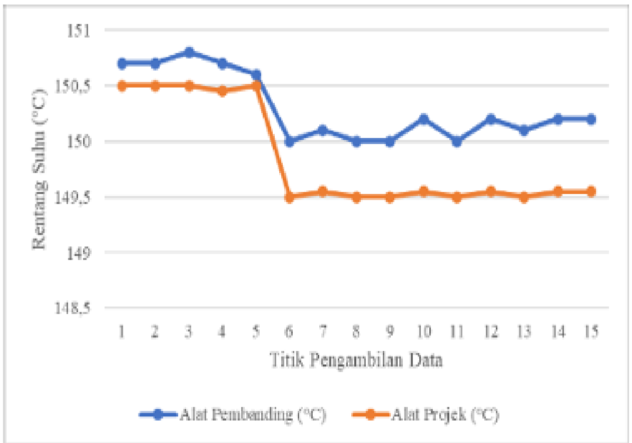

Fig 2. Comparison Chart of Measurements at 150°C

Testing the thermocouple sensor at 200°C. The test results are shown in the following table:

Tbl 2. Measurement Results at 200°C

Point	Reference Tool (°C)	Project Tool (°C)	Deviation (°C)	Error Factor (%)
1	200,9	200,75	0,1	0,1
2	200,9	200,75	0,1	0,1
3	200,7	200,65	0	0
4	200,7	200,65	0	0
5	200,9	200,75	0,1	0,1
6	199,9	199,8	0,1	0,1
7	199,9	199,8	0,1	0,1
8	199,7	199,65	0	0
9	199,7	199,65	0	0
10	199,9	199,8	0,1	0,1
11	199,9	199,8	0,1	0,1
12	199,9	199,8	0,1	0,1
13	199,9	199,8	0,1	0,1
14	199,9	199,8	0,1	0,1
15	200,2	200,25	0,1	0,1
Average	200,2	200,11	0,1	0,1

The following is a comparison graph of the 200 °C temperature test, shown in the following figure:

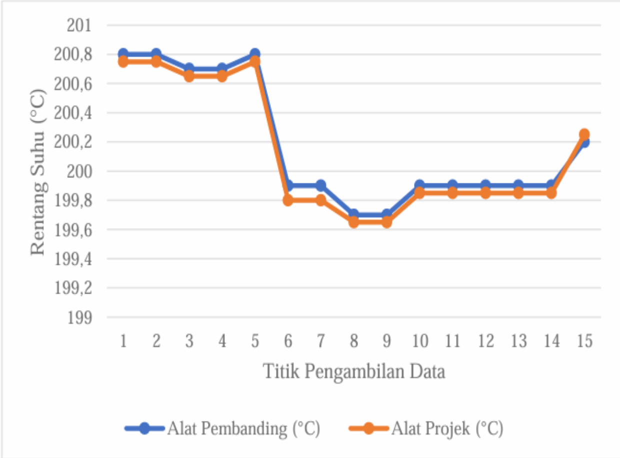

Fig 3. Comparison Chart of Measurements at 200°C

V. CONCLUSION

In this study, the development of a sterilizer calibration tool equipped with IoT has been made. The manufacture of the tool has succeeded as planned starting from the components used, the casing model used, as well as the applications made and testing the function, performance and comparative tests can be concluded that the tool is functioning properly. The process of testing the tool is carried out temperature measurement. With the research results, the deviation of temperature measurements with a setting of 150 °C has an average of 0.5 °C. For temperature measurements with a setting of 200 °C has an average of 0.1 °C. The conclusion from the testing process according to the Medical Device Calibration Work Method No. 044-18 of 2020 concerning Testing of Sterillizers is declared fit for use because it has a permissible tolerance of ± 5 °C.

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