



Recent Advances In Temperature Measurement Techniques

Abdul Muchlis¹, Nuril Hadi², Ega Nopiani Bahtiar³, Gemah Tri Prastya⁴

^{1,2} Mechanical Engineering, Faculty of Industrial Technology,

Gunadarma University, Indonesia

Email Correspondence: nurilhadi055@gmail.com

Abstract: This literature review presents a synthesis of the latest research results regarding temperature measurement techniques, including sensor technology, calibration methods, and their applications in various industries. This analysis highlights advances in the use of infrared thermometry, thermocouple-based systems, as well as digital temperature monitoring tools. Key innovations in this field include real-time temperature monitoring with IoT integration, artificial intelligence (AI)-based predictive modeling, as well as increased accuracy through statistical calibration methods. This study shows that non-contact temperature measurement methods are increasingly important, especially in industrial and medical applications. In addition, the research also highlights the influence of environmental factors on temperature measurement accuracy as well as various strategies to overcome obstacles in using sensors in various operational conditions.

Keywords: Temperature Measurement, AI, IoT, Sensors, Calibration, Thermometers

1. INTRODUCTION

Temperature measurement is an important element in various fields, from the manufacturing industry, health, to environmental monitoring. Technological developments have produced various temperature measurement systems that are more accurate and efficient, replacing conventional methods which have limitations in precision and speed. This study aims to identify current trends in temperature measurement techniques and evaluate the effectiveness of various methods that have been developed.

By combining findings from various studies, this review provides insight into the application of modern sensor technology, integration with Internet of Things (IoT)-based systems, as well as calibration methods that improve the reliability of temperature measurements in various sectors. In addition, this study also discusses the challenges faced in implementing temperature measurement technology as well as solutions that have been developed to increase sensor resistance to extreme environmental conditions.

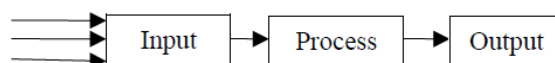


Figure 1. Research System Diagram

RESEARCH METHODOLOGY

The studies examined in this literature review used a variety of research methods including laboratory experiments, computational simulations, and statistical analysis to evaluate the accuracy and efficiency of temperature measurement systems. Several studies use this approach *cross-sectional* to evaluate the difference in accuracy between digital thermometers and mercury thermometers in a medical setting. Other research applies block diagram-based analysis to design electronic systems that enable temperature measurements with a high degree of accuracy. In addition, ANOVA tests are used in some studies to compare the performance of different temperature sensors, while regression analysis methods are applied to evaluate the relationship between temperature and other variables, such as vibration levels in industrial machines. Based studies *Computational Fluid Dynamics (CFD)* is also widely used to analyze temperature distribution in closed environments, such as industrial production spaces and vehicle interiors.

Table 1. Simulation Parameter Settings *CFD*

No	Parameter Simulation CFD	Arrangement Condition
1	<i>Type of mesh</i>	<i>Poly-hexcore</i>
2	<i>Velocity Inlet</i>	<i>Inlet 1: 1,0175 m/s Inlet 2: 1,3775 m/s</i>
3	<i>Temperature Inlet</i>	<i>Inlet 1: 21,725 °C Inlet 2: 20,15 °C</i>
4	<i>Operating Pressure</i>	<i>1 atm</i>
5	<i>Operating Temperature</i>	<i>24 °C</i>
6	<i>Time Step</i>	<i>Steady</i>
7	<i>Viscous Model</i>	<i>SST k-omega</i>
8	<i>Method</i>	<i>Pressure-based coupled</i>
9	<i>Solution Initializaiton</i>	<i>Hybrid Initialization</i>
10	<i>Number of Iteration</i>	<i>1000 iterations</i>

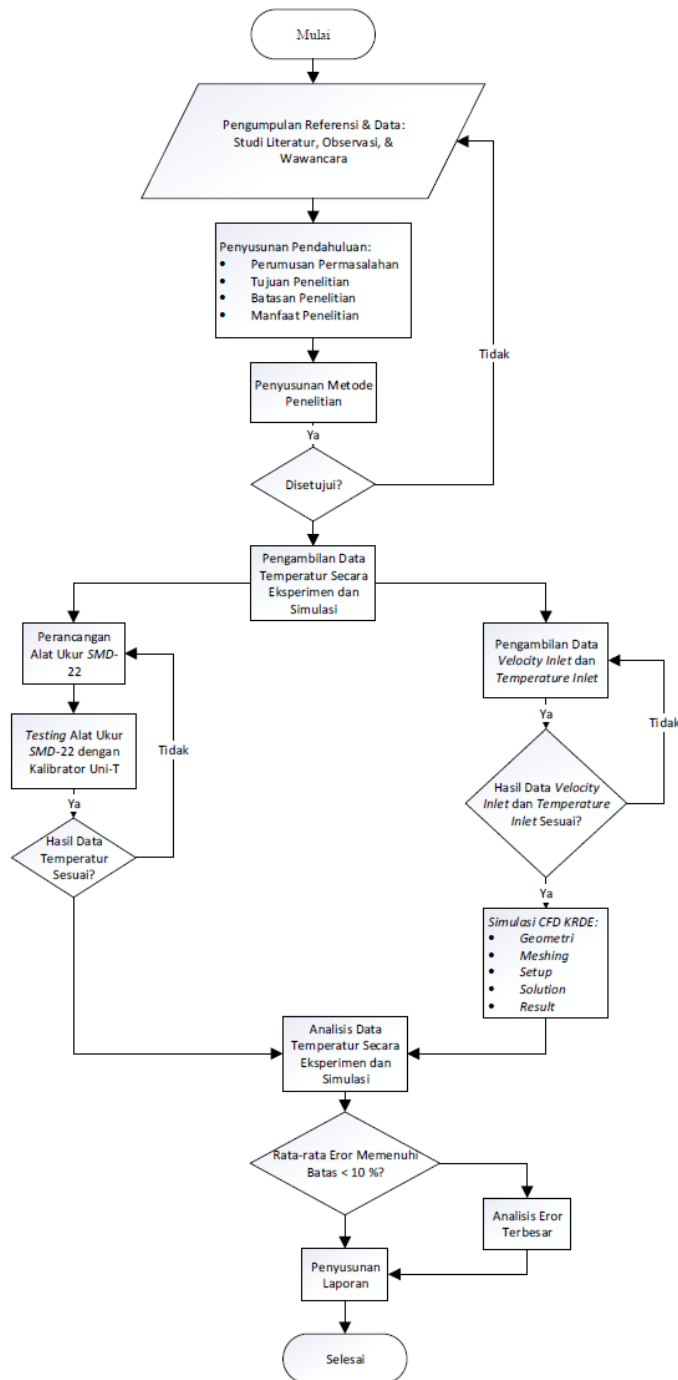


Figure 2. Flowchart Method CFD

In another study, statistical calibration methods were applied to increase the accuracy of temperature measurements by comparing the measurement results of various sensors against internationally calibrated reference standards. Some studies also use machine learning approaches to predict temperature change patterns based on historical data, which helps in long-term optimization of temperature monitoring systems.

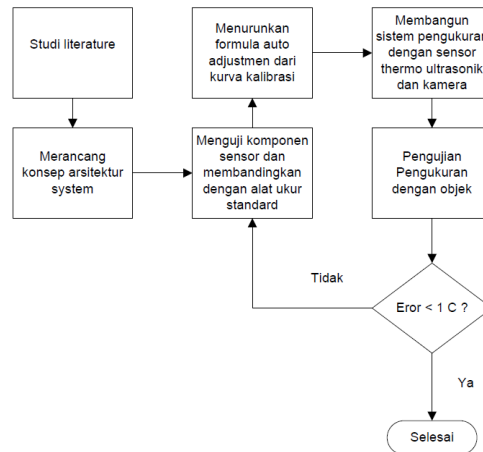


Figure 3 Research method for measuring temperature

FINDINGS AND DISCUSSION

The results of this literature review reveal several main developments in temperature measurement techniques which include the development of measuring instruments, integration of IoT-based monitoring systems, more accurate calibration methods, and the application of technology in various sectors. One of the main findings is the use of a thermocouple sensor combined with a microcontroller system, which has been shown to improve the accuracy of temperature measurements in various industrial applications. In addition, infrared thermometry technology is increasingly being used in the medical and public security fields due to its ability to measure temperature without contact, reducing the risk of contamination and increasing the efficiency of fever detection in public places.



Figure 4 K-type thermocouple



Figure 5 Arduino Uno Microcontroller

IoT-based temperature monitoring technology has also experienced rapid development. The system enables real-time temperature monitoring with data delivery to a cloud-based platform, enabling further analysis as well as rapid decision making in industrial environments. IoT-based monitoring systems have been adopted in a variety of applications, including boiler temperature monitoring, air conditioning, and temperature distribution in manufacturing facilities. Research also shows that the combination of temperature sensors with microcontrollers, such as Arduino and Raspberry Pi, allows the implementation of automated systems that can optimize temperature control in various environments.

In the field of temperature calibration, research has highlighted the importance of regression and inverse estimation methods to improve measurement accuracy. Thermobath-based calibration techniques have been developed to ensure the reliability of temperature sensors in industrial environments. The research results show that this system has a high determination value and is able to reduce measurement errors significantly.

In addition, studies have shown that environmental factors such as humidity, air pressure, and external radiation have a significant influence on the accuracy of temperature measurements. Several studies discuss strategies to reduce the impact of these factors, such as the use of thermal insulation materials in sensors as well as the application of AI-based temperature correction algorithms.

In terms of application, research shows that temperature measurement has an important role in various sectors. In the medical field, the use of infrared thermometers is increasingly widespread, especially in detecting body temperature quickly and accurately. Studies show that this thermometer can be used as an initial screening tool in detecting infections, including in the COVID-19 pandemic. In the industrial sector, temperature monitoring has been used to optimize machine performance, detect operational anomalies, and improve energy efficiency. The study also found that there is a close relationship between engine operating temperature and the wear rate of mechanical components, indicating the importance of temperature monitoring in preventive maintenance.

CONCLUSIONS AND RECOMMENDATIONS

Based on this literature review, it can be concluded that temperature measurement technology continues to develop with the integration of the latest methods that are more accurate and efficient. Advances in the development of temperature sensors, IoT-based

monitoring systems, and calibration techniques have increased the reliability of temperature measurements in various sectors. The use of infrared thermometry technology has enabled faster and more practical temperature measurements, while the use of artificial intelligence and big data analysis has the potential to increase the accuracy of temperature predictions in a variety of applications.

For further development, future research can focus on integrating AI technology in temperature monitoring systems to improve predictive analysis as well as data processing optimization. In addition, research on temperature sensors that are more energy efficient and low cost can open new opportunities in implementing temperature monitoring systems in resource-limited environments. With the continued development of temperature measurement technology, it is hoped that it can support increased efficiency in various industries and provide wider benefits for society.

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