Multi Sensor Data Fusion

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Abstract:* The subject of multisensor data fusion technology has seen a great deal of research due to the quick growth of precision manufacturing technology. The aim of this research is to improve the linear range of thermocouples and resistance temperature detectors. Each sensor measures a particular parameter, such as temperature, separately in a multisensor system. Subsequently, the system employs pertinent signal processing to amalgamate every separate measurement into an all-encompassing collection of measurement outcomes. This project aims to provide an overview of multisensor and data fusion technology and how it is used in precision monitoring systems. The increased range of thermocouples and resistance temperature detectors exhibit improved linearity as a result of the proposed technique's outcome. A multi-sensor data fusion model for temperature measurement is used in this study. The goal of the proposed project is to create a temperature measuring device that can: (a) provide accurate measurements even in the event of a malfunctioning sensor; and (b) have better performance features including sensitivity and linearity. The method is built on the foundation of multi-sensor data fusion, which includes resistance temperature detectors and thermocouples among other types of sensors. Every sensor's output is transformed into a standard representation format. A large amount of data is used to test the functionality of the implemented laboratory model. Comparing the result to a system with a single sensor, the suggested technique was able to provide a more linear and sensitive output.

***Keywords:* Multi sensor, Thermocouple, Sensitivity, RTD.**

1. INTRODUCTION

One physical factor that practically influences every natural activity is temperature. As a result, it is a crucial parameter that must be managed for any process to operate as intended. Accurate process variable measurement is required for a precise control action. Sensors and transducers, signal conditioning, and data conversion circuits (DCCs) are examples of components used in measurement. The main components that translate the actual temperature into any electrical quantity are sensors. There are several types of sensors and transducers on the market for measuring temperature. Transducer selection is frequently influenced by factors like cost, features, range, and so forth. Nevertheless, the choice frequently results in a trade-off between two or more sensor attributes.

Multi-sensor data fusion is obviously becoming more and more important in the instrumentation sector, even though a lot of the work is focused on expanding the measurement range parameters of measure. There are less published efforts in the area of enhancing measurement attributes. In light of these, the current study suggests a method for enhancing the qualities of a measuring equipment that uses three sensors thermistor, thermocouple, and RTD—are utilized in the suggested method to monitor temperature. Compared to a measuring method using a single sensor, the suggested fusion system will have better characteristics in terms of linearity, sensitivity, and fault tolerance. Multi-sensor data fusion is obviously becoming more and more important in the instrumentation field, even though much of the work is focused on expanding the measurement range and parameters of measure. There are less published efforts in the area of enhancing measurement attributes. In light of these, the current work suggests a method for enhancing the qualities of a measuring equipment that uses three sensors.

2. SYSTEM DESIGN AND HARDWARE IMPLEMENTATION

2.1. Components and Hardware Selection

• Sensors: A Type K thermocouple and an RTD (PT100) are used in the system because of their complementing properties. A wide range (up to 1260°C) and durability are provided by the Type K thermocouple, whereas the RTD gives great accuracy within a modest range (-200 to 850°C).

• Solid-State Relay (SSR): In the temperature control system, a solid-state relay is used to manage the switching functions required for high-frequency heating element control. Particularly in continuous operation configurations, the SSR's high-speed switching capability and low wear add to the system's longevity and dependability.

• Rectangular Water Bath: One tool for regulating and preserving a steady temperature in a rectangular water bath is a thermostat. By controlling the bath's heating element, it raises the water's temperature to the appropriate level. The ability to configure and store temperature settings for later use. Rectangular water baths with digital thermostats can measure temperature and give precise temperature control using thermocouples or Resistance Temperature Detectors (RTDs). For accurate temperature readings and control, RTDs are commonly found in digital thermostats. core of the system is the ladder logic diagram, which models the sequential operation of traffic lights in threedirections: East, West, and North. Ladder logic is a graphical programming language used in industrial automation, particularly for binary control systems. It mimics the physicallayout of relay-based control systems and uses symbols to represent electrical components.

2.2 Data Acquisition and Signal Conditioning

As the main data collecting device, the Radix NEX316 PID controller reads and processes the information from both sensors. By providing sophisticated PID (Proportional-Integral-Derivative) capability, this controller makes sure that automated feedback control stabilizes the temperature measurements.

3. EXPERIMENTAL SETUP

3.1 Setup

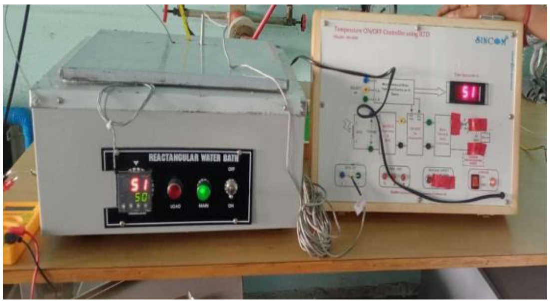


Fig.3.1 Experimental Set-up

As seen in the figure 3.1, the water bath in the lab is made up of water and a coil to change the temperature. Coordinate dimensions and measured parameter spaces (including sensors and the data conversion unit) are contributed by the first level, which is followed by the next level where pertinent sensor features are included. The next level includes methods for defining features' connections and alignment. To extract final information, composition is the last stage. In the representation stage, output is shown.

3.2 Error Analysis and Calculation

In order to assess the improvement in measurement properties, it is first exposed to standard temperatures over the measurement range under both increasing input temperature values. The temperature variation measurement readings obtained from the standard instrument and reported technique are tabulated in the table. Additionally, this table shows the percentage of mistake compared to reported and standard works. With temperature fluctuating between 45°C and 100°C under dynamic conditions of rising temperature, the output from the suggested temperature measurement technique is listed in the table.

Error percentage for each sensor was calculated as:

Error (%)=∣Measured Value−Actual Value∣Actual Value×100

For Example =

1]Actual Temperature =18 ºC
Measured Temperature=18.3 ºC
Error =?
Error percentages = |(18.3-18)/18|*100%
Error percentages = |0.3/18|*100%
Error percentages = 0.0167*100%
Error percentages =1.67%

2]Actual Temperature =24 ºC
Measured Temperature=23.5ºC
Error =?
Error percentages = |(23.5-24)/24|*100%
Error percentages = |-0.5/24|*100%
Error percentages = 0.02083*100%
Error percentages =2.08%

4. RESULTS

Tables 4.1 and 4.2 below summarize the readings from the RTD and thermocouple, along with calculated error percentages.

Sr.No	Actual temperature in °C	Measured temperature in °C	% Error
1.	45	45.2	0.44%
2.	50	50.5	1.00%
3.	55	55.6	1.09%
4.	60	60.4	0.67%
5.	65	65.3	0.46%
6.	70	69.7	0.43%
7.	75	74.2	1.07%
8.	80	80.5	0.62%
9.	8	85.1	0.12%

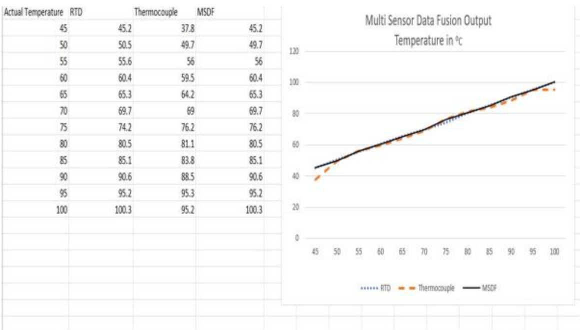
10.	90	90.6	0.67%
11.	95	95.2	0.21%
12.	100	100.3	0.3%

Table 4.1 Output of RTD Temperature Sensor

Sr.No	Actual temperature in °C	Measured temperature in °C	% Error
1.	45	37.8	16%
2.	50	49.7	0.6%
3.	55	56	1.8%
4.	60	59.5	0.83%
5.	65	64.2	1.23%
6.	70	69	1.43%
7.	75	76.2	1.6%
8.	80	81.1	1.38%
9.	85	83.8	1.41%
10.	90	88.5	1.67%
11.	95	95.3	0.32%
12.	100	99.7	0.3%

Table 4.2 Output of Thermocouple Temperature Sensor

The technique known as multi-sensor data fusion (MSDF) combines data from several sensors to produce more accurate and trust worthy information than could be obtained from a single sensor. Fig.4.1 multi sensor data fusion output temperature in ℃.



Actual Temperature	RTD	Thermocouple	MSDF
45	45.2	37.8	45.2
50	50.5	49.7	49.7
55	55.6	56	56
60	60.4	59.5	60.4
65	65.3	64.2	65.3
70	69.7	69	69.7
75	74.2	76.2	76.2
80	80.5	81.1	80.5
85	85.1	83.8	85.1
90	90.6	88.5	90.6
95	95.2	95.3	95.2
100	100.3	95.2	100.3

Fig.4.1 Multi Sensor Data Fusion Output Temperature

By combining data from many sensors, a method called multi-sensor data fusion (MSDF) generates more reliable and accurate information than could be gained from a single sensor.Multiple sensors allow MSDF to offer temperature readings with greater accuracy. The reason for this is that many sensors may have different advantages and disadvantages; by merging their data, these drawbacks can be addressed and more precise results can be obtained.

5. CONCLUSION

The sensor is a measuring technique's main component, and its properties determine how well complete measuring device performs. Sensors are chosen according to their size, sensitivity, linearity, working range, and other characteristics. It is frequently observed that choosing a sensor requires optimizing the choice by making concessions to any of the sensor's behaviors. Taking these factors into consideration, the suggested work provided a method that uses multi-sensor data fusion to produce output with better features than individual sensors.

6. REFERENCES

[1] Bhagya.R.Navada “Multi sensor data fusion for enhacement of liner range”

[2] H.B.Mitchell “Multi sensor data fusion”

[3] David .L.Hall and James Llinas “Multi sensor data fusion an introduction”

[4] Jude Hemanth “A new view of multi sensor data fusion”

[5] Usamentiaga R, Garta DF, Molleda J, Bulnes FG, Perez JM. Temperature measurement using the wedge method: Comparison and application of emissivity estimation and compensation. IEEE Transactions on Instrumentation and Measurement 2011; 60(5): 1768–78.

[6] Son KT, Lee CC. Temperature measurement of high-density winding coils of electromagnets. IET Science, Measurement and Technology 2012; 6(1): 1–15.

[7] Usamentiaga R, Molleda J, Garcia DF, Granda JC, Rendueles JL. Temperature measurement of molten pig iron with slag characterization and detection using infrared computer vision. IEEE Transactions on Instrumentation and Measurement 2012; 61(5): 1149–59.

[8] Sardini E, Serpelloni M. Wireless measurement electronics for passive temperature sensor. IEEE Transactions on Instrumentation and Measurement 2012; 61(9): 2354– 61.