Design and Build of a Temperature Monitoring System for Charcoal Burning Pipes Using Arduino Uno

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Abstract. Charcoal burning is a traditional method widely used in industries such as power generation, steel production, and manufacturing. This process involves high-risk equipment components, such as pipes that have a certain melting point limit, so continuous temperature monitoring is very important to maintain operational efficiency and safety. Anjangg village, as a producer of charcoal from mangrove tree trunks, faces air pollution problems due to the smoke produced during the burning process. As a solution, a tool has been developed that can convert smoke into liquid (liquid smoke). However, the high temperature of the smoke poses a risk to the PVC pipe material used in liquid smoke condensers which can melt at a temperature of 85°C. The tool that will be made in this research is a tool that can monitor the temperature of the pipe to help maintain the durability of the condenser pipe material. This monitoring system tool is run using an automatic Arduino Uno microcontroller system and uses a type K thermocouple temperature sensor as a temperature detection tool in the pipe. The test results show that the system is successful in detecting temperatures up to 83.75°C well, with consistent voltage when detecting smoke or not.

Keywords: Charcoal burning, temperature monitoring, type K thermocouple, arduino uno, liquid smoke

INTRODUCTION

Charcoal burning is a traditional process or method in various industries, including power generation, steel production, and other manufacturing processes. The process of burning charcoal involves many equipment components that have dangerous safety levels, one of which is a pipe that has a melting point limit, which needs to be monitored [1]. However, to maintain operational efficiency and safety, it is very important to monitor the temperature in the combustion pipe continuously.

Figure 1. Charcoal burning using bamboo

Jangkang Village is known for producing charcoal from mangrove tree branches through a burning or smoking process. During this burning process, a significant amount of smoke is generated, which can harm the atmospheric environment and contribute to air pollution. To address this pollution issue, faculty members and students have developed a device that can convert smoke into a liquid form known as liquid smoke. The Type K thermocouple is a temperature sensor that operates by generating a voltage. The temperature detected by this sensor is then converted into a voltage output. The voltage output from the thermocouple is very small, in the microvolt range. Therefore, to amplify this small voltage so that it can be read by a microcontroller, a thermocouple conditioning circuit is required. The circuit used is the IC MAX 6675, which compensates for cold junctions in the Type K thermocouple and performs amplification (enhancement), analog-to-digital conversion, and digital processing of the input signal from the T- and T+ ends of the Type K thermocouple. In the charcoal burning process, the smoke produced has a high temperature. This motivated the author to design a device for detecting smoke temperature using a Type K thermocouple temperature sensor.

METHODS

This research method includes the design and manufacturing stages of the tool, as well as evaluating its performance. This research is divided into two main phases: first, the design and tool manufacturing phase; second, the tool testing phase. The design process was carried out using Autodesk Inventor software, while tool manufacturing and testing was carried out at the Bengkalis State Polytechnic control laboratory, located on Jl. Alam River, Bengkalis. Below is Figure 1 which shows the flow diagram of the design and installation stages of the charcoal burning temperature monitoring tool.

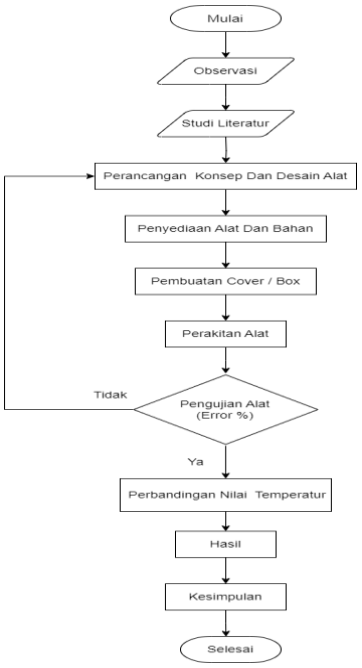

Figure 2. flowchart of the design machine with arduino

RESULTS AND DISCUSSION

When designing or making a Temperature Tool for Charcoal Burning Pipes Using Arduino Uno, it is important to pay attention that the components in this tool require sufficient power intake so that the system in the tool runs perfectly. The components are: Arduino Uno, type K thermocouple, MAX6675 module, I2C, 16x2 LCD, breadboard

and jumper cables. It should be noted that before the entire device is tested, make sure that the components are installed properly, so that when the device is supplied with a voltage source, there is no short circuit.

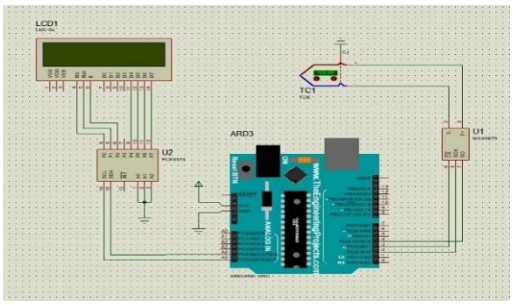

Figure 3. Concept and design

Thermocouple temperature sensor is a temperature sensor formed from two different types of metal and the ends of the two metals are glued together on a thermocouple known as hot-junction and col junction. The hot-junction functions as a measurement point. while the cold-junction serves as a reference point. In this final project tool, the thermocouple sensor used is a type K thermocouple temperature sensor. This sensor detects the temperature of the smoke in the pipe and then converts it into an analog to digital converter (ADC) value and will be automatically read by the Arduino Uno module. Displaying it is a temperature sensor that works to produce voltage. The temperature readings detected on this sensor are then converted into output in the form of voltage [3].

In this voltage data collection test, two testing times were carried out, namely testing at 12 noon and 12 at night. The following is the overall test results data:

Table 1. Test of midday

No	Nilai Temperatur			Tegangan	
	Termokopel 1	Termokopel 2	Pukul	Masuk	Keluar
1	63.00°C	49.00°C	12.00	5v	4,4v
2	64.25°C	39.25°C	12.00	5v	4,4v
3	54.00°C	55.00°C	12.00	5v	4,4v
4	83.75°C	50.25°C	12.00	5v	4,4v
5	60.00°C	44.00°C	12.00	5v	4,4v
6	57.50°C	21.25°C	12.00	5v	4,4v

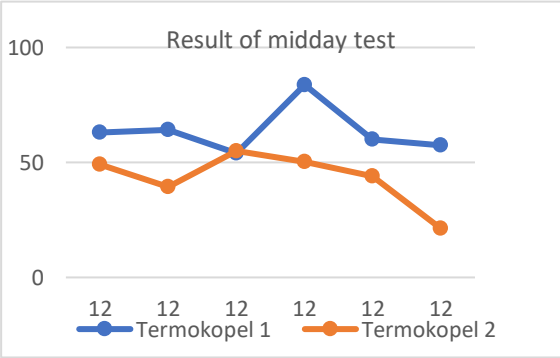

Figure 4. Midday testing result

From the graph in Figure 4.2, you can see the test results at 12 noon with a comparison value for thermocouple one, namely reaching a value of 83.75℃ and for the second thermocouple, namely reaching a value of 55℃. It can be noticed that the temperature at thermocouple one is higher than at thermocouple two.

Table 5. Result of midnight test

No	Temperature value			voltage	
	Termokopel 1	Termokopel 2	clock	In	Out
1	55.25℃	46.00℃	23.00	5v	4,4v
2	67.25℃	48.00℃	23.00	5v	4,4v
3	66.00℃	33.00℃	23.00	5v	4,4v
4	67.25℃	34.00℃	23.00	5v	4,4v
5	61.00℃	30.00℃	23.00	5v	4,4v
6	71.00℃	28.00℃	23.00	5v	4,4v

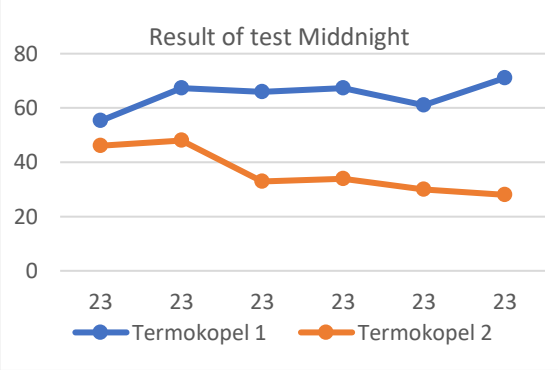

Figure 5. Result of test Middnight

From the graph in Figure 4.3, you can see the test results at 11 pm with a comparative value for thermocouple one, reaching a value of 71℃ and for the second thermocouple, reaching a value of 48℃. It can be noticed that the temperature at thermocouple one is higher than at thermocouple two.

Retrieval of error values

This data collection process aims to find out how accurate the performance of the type k thermocouple temperature sensor is when operating. Based on the voltage value of the type K thermocouple data sheet with a value range between 0℃ to 440℃, to determine the error value on the temperature sensor the author used a measurement value from 30℃ to 80℃. Error data in testing type k thermocouples can be seen in the table below.

Table 6. First error value

NO	**THERMOKOPEL TYPE-k**			
	Datasheet value (℃)	**Thermocouple Value (℃)**	**difference (℃)**	***Error* (%)**
1.	30	56,00	26	52
2.	40	63.00	23	36,50
3.	50	64.00	14	21,87
4.	60	54,00	-6	-11
5.	70	83,75	13,75	16,41
6.	80	60,00	-20	-33
Avarege				**13.79**

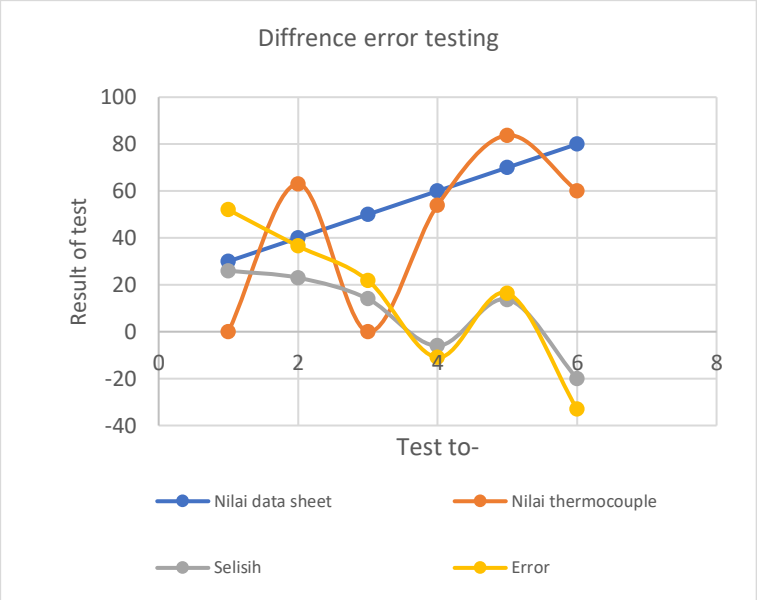

Figure 6. Chart for test the error value

Comparison Values With Umbrella Thermometer

Comparative values are taken to find out how accurate the measurement of temperature values is using a type k thermocouple. The comparison is carried out using an umbrella thermometer, where the comparison is carried out by attaching a type k thermocouple temperature sensor and an umbrella thermometer to the charcoal burning pipe, then the detected temperature value will appear on the two sensors.

Testing for data collection on temperature values on charcoal burning pipes using a type k thermocouple temperature sensor produces a temperature value of 47.75℃, while using an umbrella thermometer produces a temperature value of 48.16℃. After testing, it can be concluded that when taking smoke temperature values using a type thermocouple sensor and an umbrella thermometer, the comparison value is 0.41℃, the reading of the resulting value is more accurate using a type k thermocouple because it is used digitally.

CONCLUSIONS

The conclusions that can be drawn from the data above are as follows: In designing a temperature monitoring system for charcoal burning pipes using an Arduino Uno and a type K thermocouple sensor, the test results show that the system succeeded in detecting temperatures up to 83.75℃ well, with a consistent output voltage when detecting smoke or not. The system will monitor temperature effectively, help maintain the durability of the liquid smoke condenser pipe material, provide real-time monitoring and can increase the safety and efficiency of the mangrove charcoal burning process. In designing this tool, Arduino Uno is the main control platform which is able to process data from the MAX6675 sensor and module efficiently, and the temperature measurement results are displayed accurately on the LCD16X2.

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