Design of controlled temperature test in biochar production furnace automation

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Design of controlled temperature test in biochar production furnace automation

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Abstract. This study aims to test the temperature sensor that will be used in the biochar production furnace. Temperature testing is carried out to determine the ability of the sensor to respond to temperature changes that will be applied to the furnace. The sensors used in this system are the K-type thermocouple and the MAX6675 module. Testing is done by forming a control system. The system will be installed in the furnace by providing heating with fire in the furnace. The result of the maximum temperature was 574.25 ^{o}C at 575 seconds of heating for 1110 seconds. The test of corelation between the sensor output voltage to temperature when the temperature is raised from the beginning to the maximum, the sensor sensitivity is obtained at 5.1762 mV / ^{o}C and the slope of the graph is close to 1. Testing the relationship of the sensor output voltage to temperature when the temperature is lowered from the maximum point, the sensor sensitivity is obtained at 4.878 mV / ^{o}C and an offset voltage of 25 mV. The voltage-to-time correlation of the two tests is close to the value of 1, which means that the sensor linearity is very good so that it can be used as a temperature measurement tool.

1. Introduction

Biochar is a solid carbon-rich material that is formed through the process of burning organic matter or biomass without or with little oxygen (pyrolysis) at a temperature of 250-500 ^{o}C [1]. To produce biochar, a combustion furnace is needed which can minimize or eliminate oxygen levels in the furnace. The quality of the biochar produced is greatly influenced by the combustion temperature and the amount of oxygen present during the combustion process [2]. Therefore, it is very important to control the combustion temperature and reduce the amount of oxygen during the combustion process. This control can be adjusted from the furnace used.

The results of Adam's research [3] in India and South Africa have been able to produce a combustion device in the form of a retort kiln that is more environmentally friendly, especially in the production of emissions (Eco charcoal). Adam's retort kiln is based on the use of a separate furnace box to produce combustion heat and open space pyrolysis. where pyrolysis takes place [4]. To obtain a combustion furnace with a high temperature, the manufacture of a furnace combustion chamber or tube will be vacuumed to eliminate oxygen levels using a vacuum pump. To vacuum the combustion chamber, a compressor with adjustable pressure is used and is supported by monitoring and controlling the temperature in the combustion chamber so that the biochar combustion temperature can be controlled.

Manual control of the furnace is still not effective for the biochar manufacturing process. This causes the need for automation of the furnace system. To automate, a sensor that can adjust the temperature is needed so that combustion can be done digitally. The use of temperature sensors for combustion furnaces has been widely used for various different cases. Such as soft-sensors for titanium billet heating furnace-temperature [5], soft sensor model for reheating furnace on Relevance Vector Machine [6], and temperature measurement with thermocouple sensors based on high temperature furnace [7]. This sensor must be calibrated before being used for biochar combustion [8]. In this study, a K-type thermocouple temperature sensor and MAX6675 module were used to test the temperature of the furnace.

2. Method

The furnace automation process is completed by converting analog components into digital components. The hardware components are a K-type thermocouple temperature sensor and a MAX6675 module which functions as a cold junction. Source code is created by using Arduino software which is open source based. After the source code has been created, the code is uploaded to the microcontroller board so that the system can be controlled.

Furthermore, the sensor is tested. Tests conducted to determine the effect of temperature changes when heating for a certain time, the relationship of the sensor output voltage to the temperature from when the system reaches its maximum point, and the relationship of the sensor output voltage from the maximum point to the decrease in temperature in the system. The design of the test system is to make a design of the system by connecting the temperature control system and then see the output from the sensor. The schematic of the temperature control test system in the combustion furnace is as follows:

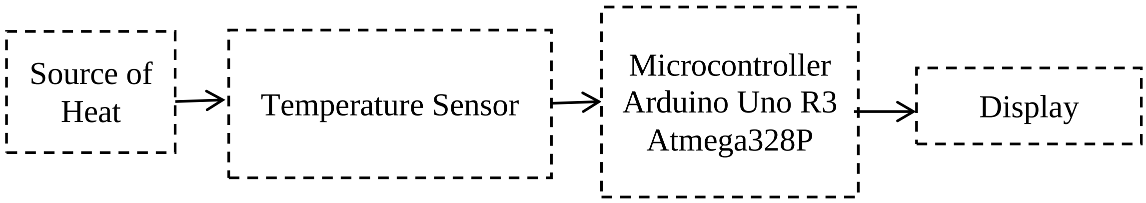

Figure 1. System Hardware Scheme

3. Result and Discussion

Testing the system that has been designed is carried out in several stages. The stages of activity in this study were system design and assembly, and system calibration with standard measuring instruments. Tests carried out to determine the effect of temperature changes when heating for a certain time interval. The relationship of the sensor output voltage to temperature from when the system reaches the maximum point, then the sensor output voltage relationship from the maximum point to the decrease in temperature in the system, and see the sensor output pulses to temperature changes.

The results of the design and testing of temperature control systems are shown in Figure 2 below. Figure 2 shows the control system test design. This system is tested by forming a system where the control system that will be applied to the biochar combustion furnace is heated by fire in the furnace.

Figure 2. Control test system design.

The relationship between temperature changes when heating for a certain time is shown in Figure 3. Figure 3 shows the relationship between the measured temperatures during the heating time. The results obtained from the effect of temperature changes when heating for a certain time interval, namely heating is carried out for 1110 seconds starting at a temperature of 30.25 ^{o}C and reaching a maximum point at a temperature of 574.25 ^{o}C, namely heating carried out for 575 seconds.

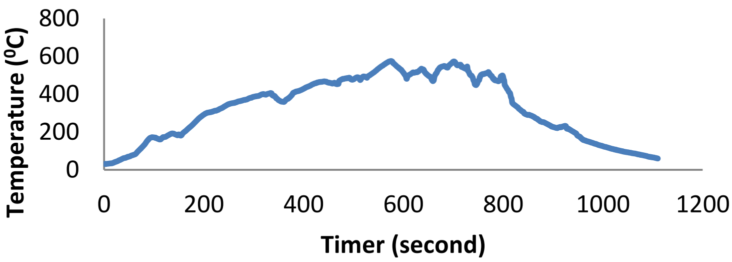

Figure 3. Relationship between temperature and heating time in the system

The relationship of the sensor output voltage to the temperature from when the system reaches its maximum point is shown in Figure 4. Based on Figure 4, the transfer function obtained shows that the sensor sensitivity is 5.1762 mV / ^{o}C. Based on the resulting linear regression value close to 1, which is equal to 0.9952. This regression value shows that the sensor linearity is very good so that it can be used as a temperature measurement tool. The resulting graph is linear, the greater the temperature given, the greater the resulting output voltage.

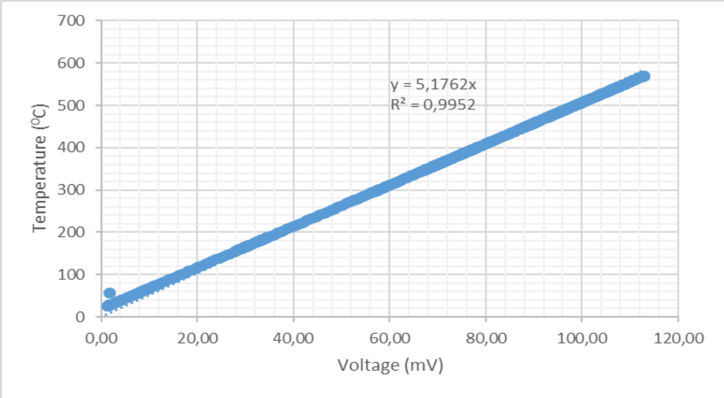

Figure 4. The relationship between the temperature and the sensor output voltage when the temperature is raised reaches a maximum point in the experiment.

The relationship of the sensor output voltage from the maximum point to the decrease in temperature in the system is shown in Figure 5. Based on Figure 5, the transfer function obtained shows that the sensor sensitivity is 4,878 mV / ^{o}C and the offset voltage is 25 mV. Based on the resulting linear regression value is 1. This regression value shows that the sensor linearity is very good so that it can be used as a temperature measurement tool. The resulting graph is linear, the greater the temperature given, the greater the resulting output voltage.

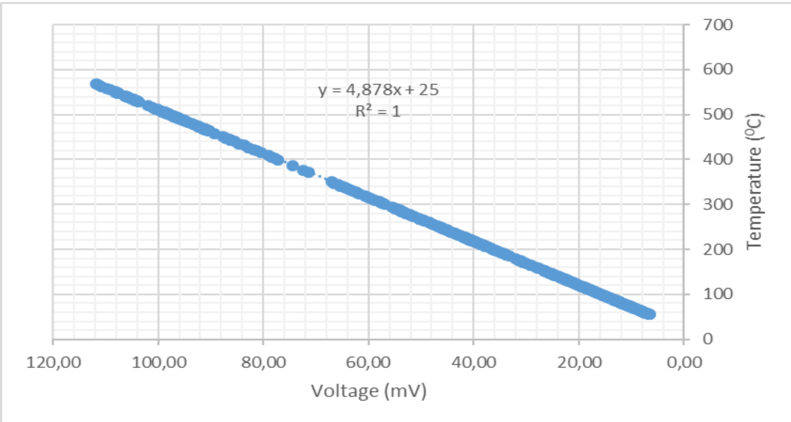

Figure 5. The relationship between temperature and sensor output voltage when the temperature is lowered after reaching the maximum point in the experiment.

4. Conclusion

In this research, temperature sensor testing for automation of the combustion furnace was carried out so that the heating process and temperature regulation could be done digitally. Sensor testing is done by looking at the effect of temperature on a certain time interval to obtain the maximum temperature, the relationship of the sensor output voltage to the temperature from the start until the system reaches its maximum point, and the relationship of the sensor output voltage from the maximum point to the temperature drop in the system. The result of the effect of temperature on time is the maximum temperature of 574.25 ^{o}C at t = 575 seconds of heating carried out for 1110 seconds.

In relation to the sensor output voltage to temperature when the temperature is raised from the start to the maximum, the sensor sensitivity is obtained at 5.1762 mV / ^{o}C and the slope of the graph is close to 1. This shows that the sensor linearity is very good so that it can be used as a temperature measurement tool. Furthermore, in relation to the sensor output voltage to temperature when the temperature is lowered from the maximum point, the sensor sensitivity is 4,878 mV / ^{o}C and an offset voltage of 25 mV. The voltage gradient against time is also close to the value 1, which means that the sensor linearity is very good so that it can be used as a temperature measurement tool.

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