Temperature Contoller in Portable Boxes using PID (Poportional Integral Derivative) Methods

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A B S T R A C T

Many foods become unhealthy because they are contaminated with unsafe ingredients or with containers that are not suitable for use. One of them is by using plastic media, which often happens to workers and children when buying food carelessly. So it takes food supplies to still be able to control what is consumed. But many parents are not aware of the dangers of plastic being used to store food. Not only that, when the provisions use plastic media, the food cools very quickly in a matter of hours. So you need a food heater to keep it warm and fresh when consumed. Where a food box warmer can warm food in a short time of 15 minutes, using a PTC (Positive Temperature Coefficient) heating element to get a temperature value of 49 ℃ using the PID (Propotional Integral Derevative) method which is used to get an error value and has a response stable system. PID can provide control with good accuracy during the heating process. So that the results of several experiments obtained a set point value of 49 ℃ which has a stable temperature with an error rate of 0.69

Keywords: PTC heater, PID, control, battery, LCD.

1. Introduction

You could say that the existence of food can increase the potential abilities of children, both in the academic and non-academic worlds. To fulfill children's nutrition, a place was built so they can enjoy healthy and of course, safe food, which is known as a healthy canteen. Not only student workers, also have to pay attention to diet because workers have very busy jobs. In fact, students and workers prefer to eat ready-to-eat food, which causes them to have various kinds of health complaints ranging from stomachache, diarrhea, and cholesterol. This of course, also has a bad impact, so food supplies need to be used.

Food supplies are important for mothers to oversee food in the family. In order to get nutrition, and food safety, and when traveling, you don't need to worry about your diet because it is maintained even when traveling outside the city for vacation or for work and school supplies. Currently, there are many places for large quantities of provisions, so mothers can still provide the right food and easily monitor nutrition when consuming food. It is not good to place hot food in containers containing plastic. However, many places to eat themselves use it because the media used has bacteria, which will eventually become a health problem [1]; besides that, plastic containers are also able to withstand heat within 5 hours by closed container [2]. This of course, reduces the freshness of the food, especially with the

cover of the container where the air inside cannot get out will cause the food to spoil quickly when consumed for more than 5 hours [3].

Based on the explanation, this study aims to control the heat temperature of the lunch box, so that the food is kept warm when the temperature starts to decrease. The feeding box uses heat control with a PTC heater to get a heat source. In addition, the lunch box uses the PID method on the heating system to get the set point error value and system response to temperature control, to control the temperature of the lunch box stably with a predetermined set point at 49℃. The power source in the feeding box using a lipo battery is used as a PTC heater heat source.

Lipo batteries are used because they have enough power in the lunch box when they run out they can be charged and used again. The reduced power can be seen through the OLED LCD on the wooden box. The box has a steam exhaust in the form of rubber to make it easier for water to escape so that the water obtained during the experiment does not drip directly and does not cause spoilage in the provisions. The box is designed by providing space for the heating element so that the water attached to the lid dries, and when the temperature reaches 49 ℃, the food is said to be warm or has finished heating. This can be seen on the OLED LCD..

2. Methods

The lunch box that will be used uses stainless steel 304 for food containers to speed up heat gain. Type 304 has 99% pure aluminum content,

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with a 1% metal mixture so it is safe to be used directly in food and beverage packaging [18]. This food box has two chambers, the first is the most basic room containing a PTC heater for the food to get heated, and the wooden part has a large enough space for component placement. The provision of glass wool aims to avoid touching the components with heaters so that the components are not easily damaged, besides that the provision of glass wool aims to maintain a hot temperature when the appliance is turned off. The lid has a valve equipped with a heating element to produce no more than 2 ml of steam so that the steam does not wet the food in the lunch box, which can cause the food to spoil quickly.

The temperature achieved by the set point is up to 49 ℃. System control uses the PID method to control the temperature which is obtained as a heating medium using a PTC heater as a source for the lunch box. Resources used for portability and efficient energy sources from batteries can be charged to get more resources. The battery can be used 3 times to warm up; the wooden part of the lunch box is equipped with an LCD, where the LCD is used for readings when the battery is running low so that the user can see the battery power that will be recharged. The system process used in this study is as follows:

A. A temperature sensor as PTC heater Input, each component is used to get the PID value.
B. The sensor value read by the Arduino Mega 2560 Pro Mini will then be processed using the PID method to become the actuator input value.

2.1. Lunch box design

The design of the lunch box is the design of the lunch box or lunch box in order to know the design, size, shape, and layout of the lunch box so that the system works properly. Making the design of the tool makes it easier when it is made in a lunch box. The tool design itself uses 360 fusion for maximum results, which can be seen in Figure 1, which is a lunch box design.
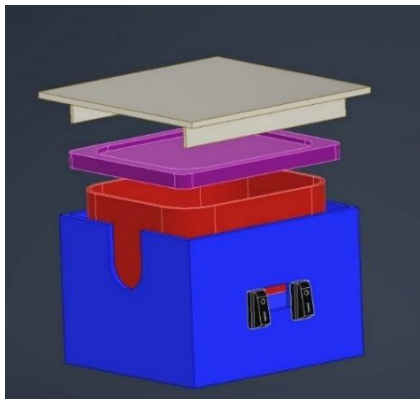

Figure 1. Overall part of the lunch box

The overall result of the food box is that it has a cover made of wood so that heat does not come into direct physical contact, and has a stainless steel 304 cover. In Figure 2, it can be seen that the inside has a second cover for food so it doesn't spill easily on the dining area itself, which has a diameter of 23x12x8 cm³ which is spacious enough for food so that it can store food several times. In addition, the outer layer of wood with a diameter of

24x20x12 cm³. Tepak Makan also has an on-off button so that the temperature reaches warm so it can be turned off to save battery. On the outside it is also equipped with an LCD which can be used to find out the warm temperature that has been reached. The inside of the pate uses 304 stainless steel to keep warm.

Figure 2. Cover on the lunch box

In Figure 2. it can be seen that it has a steam hole or valve that can be opened during the process of heating food, which functions for the passage of water, preventing it from accumulating in the lid so that what is obtained will enter the hole to avoid accumulation. The cover itself is equipped with a heater so that the drying part of the cover does not have steam and cannot drip on the food. The cover itself has a top layer of wood to avoid direct contact with the body and additionally covers the top heater.

2.2. Control block diagram

The working principle of the system is in accordance with the application to be carried out, with a block diagram it makes it easier to know the set point, input control and output control. The initial process that gets sensor readings is used as Arduino 2560 pro mini input to process input values with the PID method. So get the error value that will be used as the appropriate output for the actuator controller. The following control block diagram is shown in Figure 3.
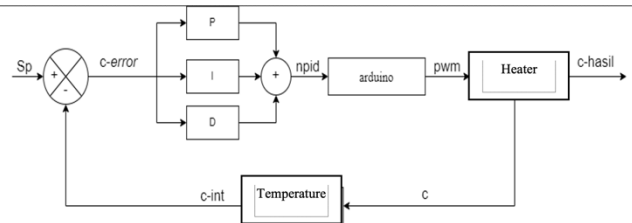

Figure 3. Control Block Diagram

The ds18b20 temperature sensor value obtained will be sent to Arduino for processing, when the temperature reaches the set point, the MOSFET module will activate to control the heater and display on the OLED LCD, all data obtained is stored on the micro sd. In the block diagram, the battery input system then gets a response from Arduino to be processed so that it powers each component that is turned on.

2.3. Meal Box PID System Flowchart

The flow of the system running the tool as a whole is shown by the flowchart of the feeding box system in Figure 3.4, starting with determining the temperature set point value and providing an introduction to some of

the variables that will be used in the program code. The temperature sensor will start reading the temperature in the food box when the device is turned on, then the Arduino microcontroller will compare the temperature value obtained from the sensor with the set temperature set point so that the error value is obtained from the difference between the temperature set point and the sensor reading results. The error value that has been obtained will be processed using the PID method to get the error value.
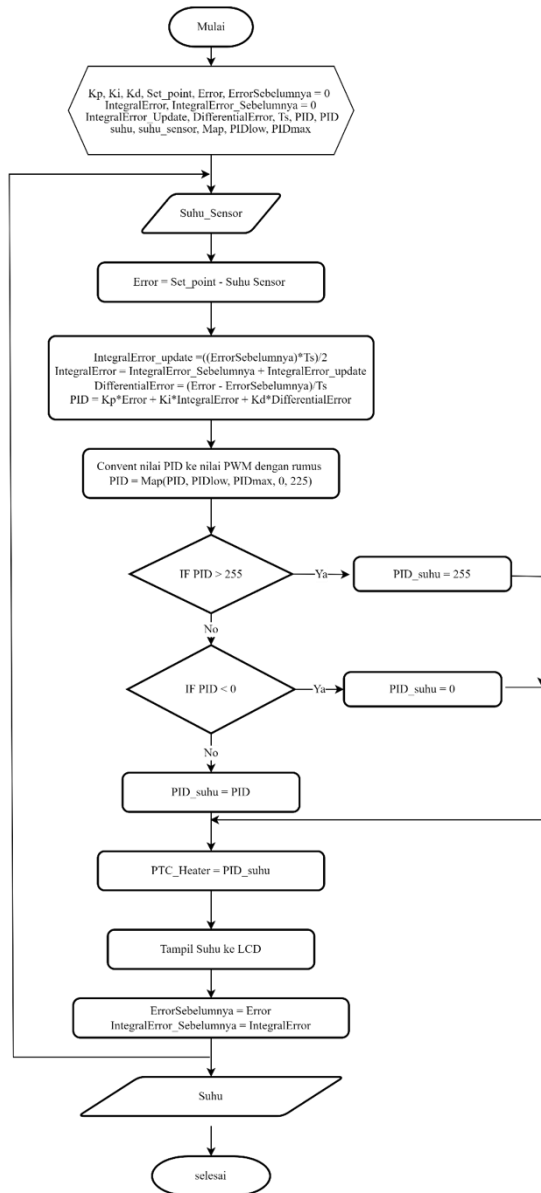
Figure 4. Meal Box PID System Flowchart

The smaller the error value indicates that the temperature in the food box is close to or in accordance with the desired temperature set point. In the process of calculating the PID method, the search for the value of the Proportional equation (P) is obtained by giving the proportional control value (Kp) to the error value that has been obtained, for the Integral

equation (I) that is by giving the integral Control value (Ki) to the sum of the error values with the the previous error, and for the Derivative equation (D) is obtained by giving the Derivative Control value (Kd) to the difference in the error value obtained with the previous error value. The previous error value that was first initialized at the beginning of the program has a value of 0 because there is no previously known error value. The three results of the P, I and D equations combined will form a PID control so that the system can run properly and produce a stable output.

The results of the PID calculation process will then be mapped in the Arduino program code to produce a PWM (Pulse Width Modulation) value with a range of 0 to 255. The PWM output obtained will be used to adjust the amount of heat generated by the PTC heater. The error value previously obtained from the difference between the temperature set point and the temperature value obtained by the sensor will be stored in the previous Error variable and the Integral error value previously obtained from the process of adding the error value to the previous error value will be stored in the Integral Error_Previous variable. The temperature PID control process will continue until the sensor temperature value matches the temperature set point previously set. In the iterative process to get the temperature value according to the set point, the sensor will continue to read the temperature in the food box so that the error value will continue to be updated to get the smallest possible error value. The smaller the error value indicates that the temperature has reached or is approaching the temperature set point.

3. Result

The result of making the tool is a series of overall shapes that have been designed to be able to run according to the process of making the tool by carrying out several stages in order to produce a control tool. The stages of making a control device include mechanical design, electronics design and tool programming. The results of making the entire tool can be shown in Figure 5.

Figure 5. The Result of Eat Meals

Overall description of the palm fruit Figure 5:
1. Rubber side cover.
2. Rubber or valve parts cover.
3. Stainless steel inner plate.
4. Outer wood.
5. Wooden cover.

3.1. Device Testing Using the PID method Not Using Rice

This test finds a value that is quite appropriate during testing. The initial test results used a set point of 49 ˚C when the system was run at an initial temperature of 45 ˚C. Obtaining a fairly low error value of 3.22

and obtaining a maximum temperature value of 58 ˚C the results obtained in this experiment have a fairly stable value so that it has an error value of 0.69 with a rise time of 1 minute 94 seconds. Where when the temperature starts to rise the temperature reaches an overshoot of 58 ˚C and gets a decrease for temperatures approaching the set point up to 49 ˚C. The settling time obtained was 19 minutes 31 seconds and the steady state value was obtained at 23 minutes 17 seconds in the 37 minute heating experiment can be proven in the graph of Figure 6.
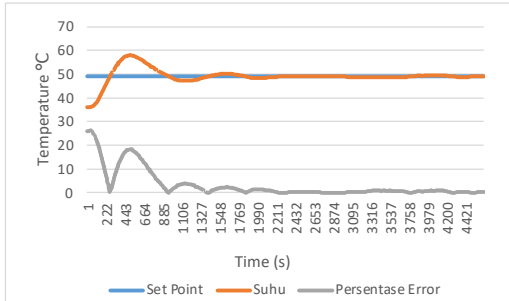
Figure 6. Search test for Kp = 12, Ki = 0.7 and Kd = 1.5

The test results in Figure 6 with trial and error of Kp = 12 Ki = 0.7 and Kd = 1.5 these parameters are used in the system with results such as graphs that prove if the values can be used in the system. The room temperature value obtained at the initial system is 38 ℃ until it rises at the initial time of 1 minute the temperature exceeds the set point reaching 60 ℃ to 4 minutes and the temperature begins to decrease until it is less than the set point at 59 ℃. The values obtained began to stabilize at 12 minutes with an experimental time of 36 minutes 81 seconds. So that the trial and error values can be used in the system because the temperature obtained is stable with the specified set point.

3.2. Testing the Best Temperature Experiment Results as well as the Lowest Error

The results of searching for temperature values have several experiments with different set point values at the same time as searching for error values, from the results obtained at different times each has a maximum temperature according to the experiment. With the test set point this time getting the error value, the results of the experiment are run on the system. The experimental results can be seen in Table 1. The search for the appropriate set point temperature value.

Table 1. The results of the search for the best temperature as well as the search for error values

Test to	Set point ˚C	Max Temp ˚C	Long time hot experiment (Minute)	% error ˚C
1	35	34,81	43	0,5%
2	38	37,88	35	2,4%
3	40	40,31	34	4,94%
4	49	50,23	37	2,05%
5	50	50	29	4,08%
6	55	55,89	36	18%
7	60	50,96	36	5,83%

All experimental results with each set point have a different error value, so it can be concluded that the system used is shown in Table 1 shown in number 4. Where the set point value is 49, you get a fairly small error of 2.05 with a good time trial . There are several set point values that are not used in the system because the temperature set points number 1, 2 and 3 have less hot temperatures as well as a large enough error value to reach 4.94. The temperature set point value in sections 5, 6 and 7 has a fairly hot temperature but at this temperature the rice dries quickly when heated 3 times, then the temperature set point value in this section cannot be used because it has a large maximum error value, namely 5.83.
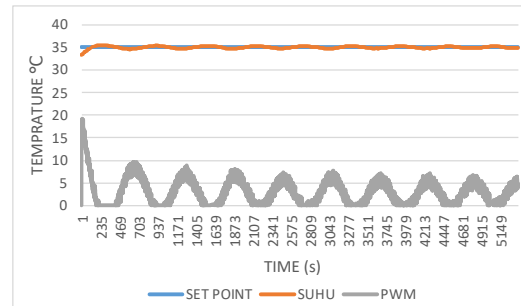

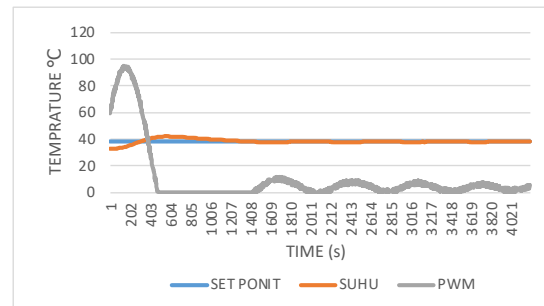Figure 7. first test temperature 35 ˚C
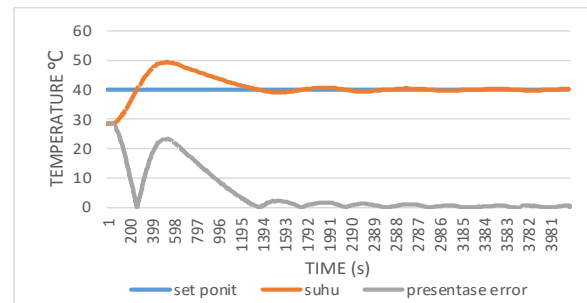

Figure 8. second test temperature 38 ˚C

Figure 9. The results of the temperature experiment at 40 ˚C
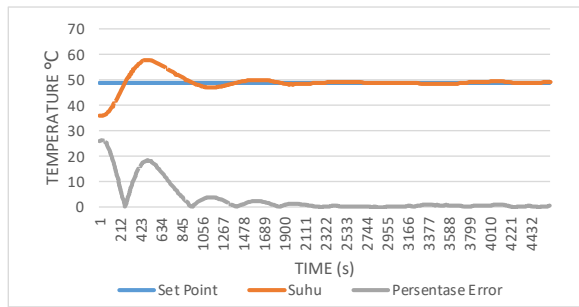
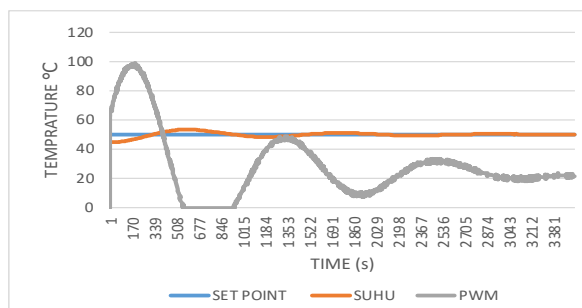Figure 10. Test results at 49 ˚C
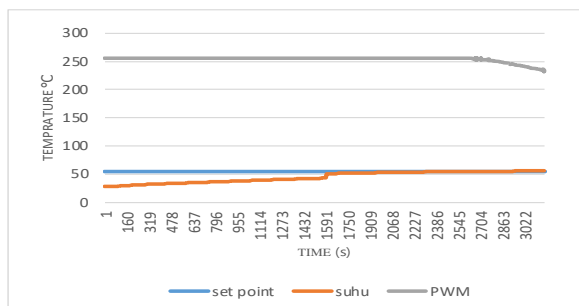

Figure 11. fifth test 50 ˚C

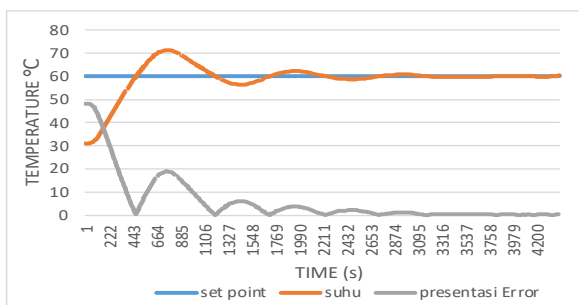Figure 12. sixth test Temperature 55 ˚C

Figure 13. Test Results temperature 60 ˚C

4. Conclusion

Based on the tests and results of the analysis that has been carried out in the final project research, it can be concluded that the control device can run automatically during the heating process in the feeding tray starting when the control device receives the test results for 37 minutes with a set point of 49 ℃ on the feeding tray controller and has a higher steam temperature. don't wet the room. Then, to get good test data, it is necessary to try the temperature repeatedly on different elements with an accuracy level and not have a large error. PID control can provide stability to the system for temperatures that can reach the specified set point. So get the temperature value with a fairly small error reaching 0.69. Lastly, there is glass wool for the temperature defense process during the cooling process, so that it retains heat in the pate for longer, up to 2 hours..

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