Solar-powered automatic oven machine for chili and ginger drying in the highland

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Received: 1 September 2024 Revised: 22 October 2024 Accepted: 24 December 2024

Abstract— Chillies and ginger are plantation crops in mountainous areas. One form of processing is by drying. The purpose of drying is to reduce the water content of plantation products. Natural drying requires the sun as a heating source with temperatures around 50˚C-60˚C, which is a problem in the mountains because the temperature is below average so it takes a long time. Natural drying has a dependence on sunlight and also a low level of hygiene. In this Research, a solar-powered Automatic Oven Machine prototype is made for chilli and ginger drying in mountainous areas. The solar-powered system as a supplier of electrical energy uses a solar panel Automatic Transfer Switch system. The selection of the title Automatic Solar Powered Oven Machine for Chilli and Ginger Dryer in Mountainous Areas aims to solve the problem of drying in mountainous areas which can cause a decrease in price and quality due to spoilage. The time used for testing this research tool is 6.53 hours, so the power required is 1506.95 Wh. The results of this study obtained the static characteristics of the temperature sensor have an accuracy of 99.21% and an error of 0.79%, while the weight sensor has an accuracy of 99.36% and an error of 0.64%. Max. overshoot at set point 50OC is 6.44% with a stedy state error of 5.46%.

Keywords— Machine Oven, Automatic Transfer Switch, Solar Panel.

1. INTRODUCTION

Chilli is a food commodity that is always needed by the community every day. It is not surprising that this commodity is often the cause of price increases because its price often fluctuates when following the amount of production and daily distribution [1]. The use of chillies such as dried chillies as an alternative to chilli consumption is voiced by farmers to avoid the fall in chilli prices when the harvest season passes. To make dried chillies, of course, requires a drying process that uses heat energy from the sun. Drying is one of the processes to extend the life of agricultural products without losing their nutritional properties before consumption. The time required for drying whole chillies ranges from 20-25 hours at 60˚C while for cut or split chillies it takes 10-15 hours [2].

In addition to chillies, an agricultural product in mountainous areas is ginger. Ginger is a useful ingredient in various purposes, such as beverage ingredients, food mixtures. One of the products of ginger is simplisia. Ginger simplisia is ginger that has been dried with the aim that the product can be stored for a long time and also does not reduce its active substances in accordance with the parameters of the Ginger Simplisia Quality Standard (SNI 01-7084-2005), namely a maximum moisture content of 10% by weight and a minimum essential oil content of 1.5% by weight [3]. The current problem is unable to achieve market demand due to the inability to increase production capacity. This is due to the slow and failed stage of the ginger drying process. In addition, due to the natural or conventional method of drying the product by drying on the floor, the quality of the product is low, the level of dryness of the product is not uniform and depends on sunlight.

2. Previous Researches

In previous research related to ginger dryers using desiccant rack dryers, the research still uses LPG gas for fuel and uses PLN electricity sources completely to turn on the equipment. In previous research related to the model test of a rack-type dryer with a solar collector, the drying process uses a solar collector as a heater by utilising solar radiation directly, of course, it still has the nature of dependence on sunlight. Therefore, in this study, a device was built that is expected to be able to overcome the drying of chillies and ginger in mountainous areas. In previous research related to the selection of lamps as heaters in baby incubators, the results of ordinary incandescent lamps with 60 watts can produce an average temperature of 51.4 ˚C in a special room measuring 120cm x 120cm x 120cm [4-10]. This is the basis for choosing incandescent lamps as a heat source for the dryer.

3. Method

3.1. Research Flowchart

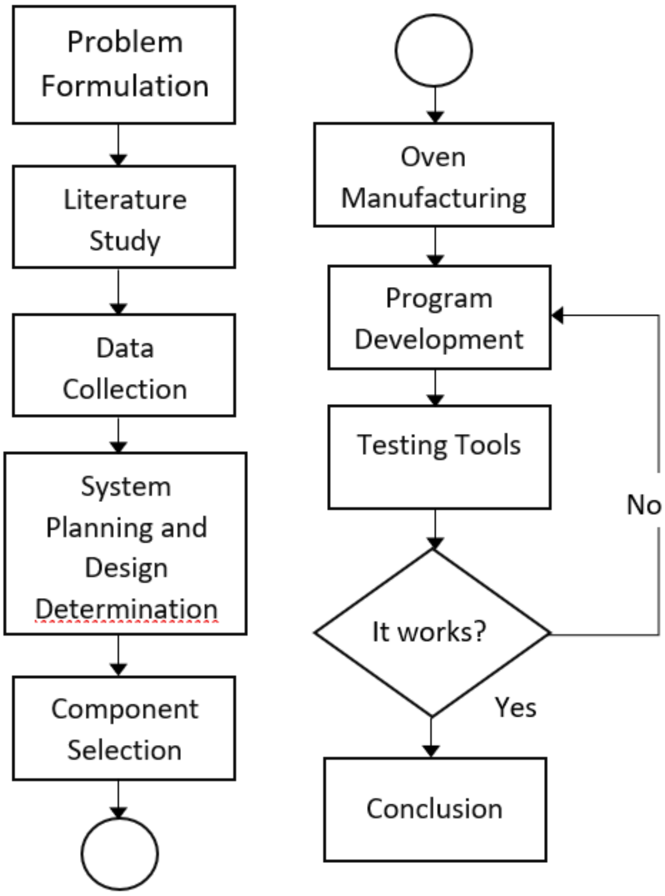

Figure 1 Research Flowchart

3.2. Details of Research Methodology

- Literature study on the right theoretical basis in designing tools or processing control systems and measurement systems using the Arduino Uno microcontroller.
- System design and design determination regarding the design of a temperature control system in a solar-powered Automatic Oven Machine plant for chilli and ginger dryers in the mountains.
- Perancangan and hardware manufacturing is the stage of compiling the design of the control and measurement system related to the drying oven machine. The arrangement is based on components that have been selected. The selected components are connected to each other between the sensor and the controller, the actuator with the controller and the display with the controller.
- Tool testing on the solar-powered Automatic Oven Machine plant for drying chillies and ginger in the mountains. With details of testing the sensors used in this plant and controlling the temperature.
- Data analysis that has been obtained during the automatic oven machine test, then the data is analysed for the readings of each sensor and actuator.
- The conclusion is a discussion of the activities that have been carried out in accordance with the data that has been obtained then a conclusion is obtained that covers the content of the research that has

been carried out.

4. RESULT AND DISCUSSION

4.1. Testing of static characteristics of temperature sensor (IC LM35)

Testing the LM35 IC is carried out in order to determine the difference in output between the object being measured and the input, this is to determine the comparison of values between two different variables. Temperature sensor testing is done by giving an increase in temperature in the oven room. The data obtained is as follows:

Table 1 Temperature Sensor Read-out Data

Minute	Input Celcius		Output mV		Non Linearity	Hysteresis
	Raise	Fall	Raise	Fall		
0	34.67	65.43	70	134	-0.0136	64
1	38.57	64.94	79	134	0.8744	55
2	41.99	64.45	87	132	1.7608	45
3	45.9	63.48	94	130	0.628	36
4	48.34	62.99	99	128	0.5528	29
5	50.78	62.5	104	128	0.4776	24
6	51.76	62.01	106	126	0.4392	20
7	54.2	61.52	110	125	-0.636	15
8	55.66	60.55	114	124	0.3272	10
9	57.13	59.57	118	122	1.2696	4
10	58.11	58.11	120	120	1.2312	0
11	59.57	57.13	122	118	0.1944	-4
12	60.55	55.66	124	114	0.156	-10
13	61.52	54.2	126	110	0.1384	-16
14	62.01	51.76	125	106	-1.8808	-19
15	62.5	50.78	128	104	0.1	-24
16	62.99	48.34	130	99	1.0808	-31
17	63.48	45.9	128	94	-1.9384	-34
18	64.45	41.99	132	87	0.044	-45
19	64.94	38.57	134	79	1.0248	-55
20	65.43	34.67	134	70	0.0056	-64

From table 1 of data collection up and data down the IC LM35 temperature sensor readings, the static characteristics of the sensor are obtained as follows:

a. Range: 34.67 - 65.43 ˚C
b. Span: 30.76
c. Sensitivity: 2.08 mV/˚C
d. Max. Non Linearity: 0.03
e. Max. Hysteresis: 100 %
f. Accuracy: 99.21 %
g. Error: 0.79 %

From the data that has been taken above, the results of data collection from the LM35 IC sensor are obtained with an initial temperature of 34.67 ° C and a final temperature of 65.43 ° C so that the span obtained is 30.76. From the above calculations, the sensor accuracy rate is 99.21% and the calculation error is 0.79%. In addition to the static characteristics of the temperature sensor measurement, a dynamic response of the actuator performance to the set point is also obtained.

Testing the actuator response to the set point is done to see how the temperature control system works to keep the setpoint at a temperature of 50 °C. The results are as follows:

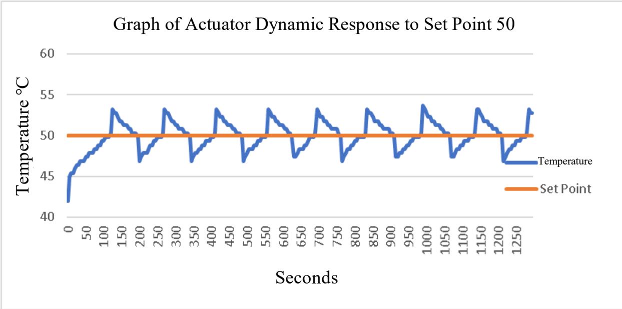

Figure 2 Graph of Actuator Dynamic Response to Set Point 50

From Figure 2 of the graph above, the results of the dynamic response test using a set pointt of 50 °C in the figure show that the graph has increased and decreased (Oscillation) the temperature to reach the set pointt. This is because the control mode I use is ON / OFF. From the picture, the dynamic response data is obtained as follows:

- **Max. Overshoot:** 6.44%
- **Steady State Error:** 5.46%
- **Rise Time:** 2nd minute
- **Setling Time:** Does not reach steady because there are no tools that can circulate hot air out of the drying chamber when over temperatrure occurs and also the control mode used is On/Off.

Testing the actuator response to the set point is done to see how the temperature control system works to keep the setpoint at a temperature of 65°C. The results are as follows:

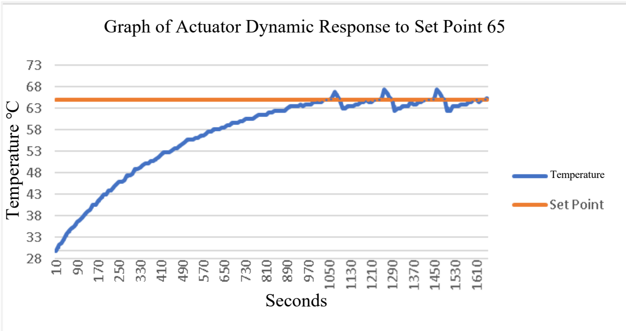

Figure 3 Graph of Actuator Dynamic Response to Set Point 65

From Figure 3 of the graph above, the results of the dynamic response test using a set point of 65°C in the figure show that the graph experiences an increase and decrease in temperature to reach the set point. This is because the control mode that use is ON / OFF. From the picture, the dynamic response data is obtained as follows:

- **Max. Overshoot:** 3.7%
- **Steady State Error:** 0.6%
- **Rise Time:** 17th minute
- **Setling Time:** Does not reach steady because there are no tools that can circulate hot air out of the drying chamber when there is over temperatrure and also the control mode used is On/Off.

4.2. Testing of static characteristics of weight sensors

Load Cell weight sensor testing is carried out in order to determine the difference in output between the object measured with input that has the same weight, this is to determine the difference in value between two different variables. Weight sensor testing is done by providing the same weight input. Load Cell weight measurement results are compared with standard measuring instruments in the form of digital scales. The difference between the value read by the Load Cell and the standard measuring instrument will be assumed to be the error value. The data obtained is as follows:

Table 2 Weight Sensor Read-out Data

Num	P in (gr)	P out raise (gr)	P out fall (gr)	H (I)	Average (gr)	(Pin - Pout) /Pin
1.	160	159.78	159.8	0.02	159.79	0.0013125
2.	251	250.02	250.12	0.1	250.07	0.003705179
3.	503	502.48	502.54	0.06	502.51	0.000974155

Total	0.18	912.37	0.005991834
Average	0.06	304.1233333	0.001997278

From the data in Table 2 above, the static characteristic values of the device are obtained as follows:

a. Range: 159.78 - 502.48 grams
b. Span: 342.7 grams
c. Sensitivity: 0.99
d. Max. Hysterisis: 0.02%
e. Accuracy: 99.36 %
f. Error: 0.64%

4.3. Tool Testing

Data collection is done in order to find out the comparison between the objects measured, it is to find out the value comparison between two different variables, namely the weight of the object being dried and the temperature in the drying chamber. The following is one of the data from testing the tool in the form of drying 101 grams of ginger:

Table 3 Tool Testing

No	Minute	Temperature (ºC)	Weight(gr)
1	1	35.64	101.66
2	5	47.36	101.77
3	10	49.32	88.07
4	15	49.8	84.62
5	20	51.76	73.84
6	25	48.83	64.14
7	30	49.8	53.55
8	35	51.76	41.37
9	40	48.83	32.81
10	45	45.41	11.79

From table 3 above, there is a decrease in weight from 101 grams of ginger to 11 grams of dried ginger. The process takes 45 minutes to obtain 10% moisture content. Using a set point of 50˚C, the temperature rise and temperature control can be seen in the following graph.

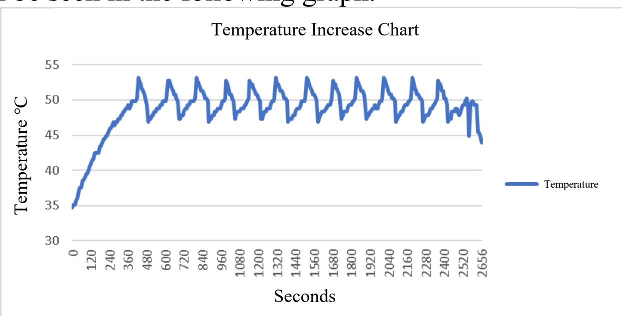

Figure 4 Temperature Control System Chart

In Figure 4, there is an increase in temperature from the initial temperature of 35˚C to the set point. There are oscillations between set points on the graph due to the control mode used which is On/Off.

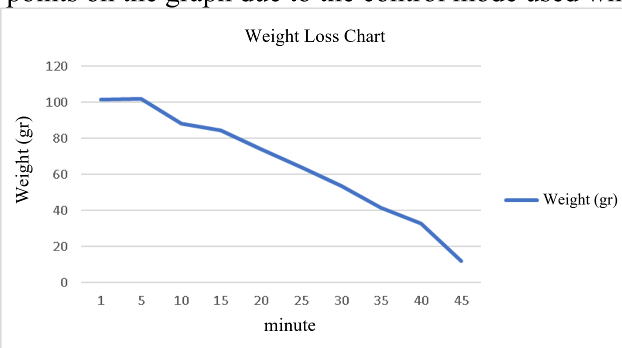

Figure 5 Drying Process Weight Loss Chart

From Table 3, the weight loss graph of the dried ginger is shown in Figure 5. The data graph is taken every 5 minutes to determine the weight loss that occurs during the drying process.

4.4. Electricity Requirement for Drying

In this research, 2 bulbs with a power of 60 watts and 1 bulb with a power of 100 watts were used. Where 3 bulbs as the main heating source to produce temperature in the drying room.

Table 4 Total energy required

Load	Hours	Power (W)	Total	Energy (Wh)
Lamp 60 watt	6.53	60	2	756
Lamp 100 watt	6.53	100	1	653
Supply Arduino	6.53	20	2	261.2
Total Energy				1670.2

- Panel capacity = ET / solar insolation
  KP = 1670.2 Wh / 3.5 = 477.2 wp
  Number of panels = 477.2 wp / 150 wp = 3.18 ~ 3 panels
- Battery capacity = ET / Vs = 1670.2 Wh / 12 v = 139Ah
  Cb=(Ahxd) / DOD = (139 Ah x 1) / 0.8= 174
  Ah Battery quantity = 174 / 80 = 2.17 ~ 2 Batteries
- SCC Requirement
  Short Circuit Current (Isc)= 7.42 A
  SCC= 3 x 7.42 = 22.26 A

In table 4 above, the electrical energy required to dry the 6 objects of different ages is 1670.2 Wh. The capacity of solar panels needed is 3 solar panels with a capacity of 150 wp. The battery capacity needed to accommodate electricity from solar panels is 174 Ah. So the number of batteries used is 2 batteries with a capacity of 80 Ah.

5. CONCLUSION

Based on the formulation of the problem and the results of the analysis, the conclusions obtained from the final project of the solar-powered automatic oven machine for chilli and ginger dryers in mountainous areas are that the tool can dry chillies and ginger with different set points, namely chillies using a set point of 65˚C while ginger is 50˚C. The drying produces a product that has a moisture content of 10%. The time used for testing this final project tool is 6.53 hours, so the power required is 1670.2 Wh. From the required power requirements, the required solar panel capacity is obtained, namely 3 panels with a capacity of 150 wp.

In the dynamic response test using a set point of 50˚C, a Steady State Error value of 5.46% is obtained. This is because the control mode I use is ON / OFF, so the Max. Overshoot obtained is 6.44%. While testing the dynamic response using the 65˚C set point, the Steady State Error value of 3.7% is obtained. This is because the control mode I use is ON / OFF, so the Max. Overshoot value obtained is 3.7%.

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