Smart Control of Temperature and Humidity for Opak Dryer Oven

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Abstract. Cloudy or rainy weather will minimize the sun’s radiation to the ground. It will affect to production level of Opak by Micro, Small and Medium Enterprises (MSMEs). They do conventional drying processes using sunlight and it needs a large drying area. The drying process using an electric oven equipped with an automatic temperature detection and control system, it called the Smart COpak, is an effective and efficient method. This system will detect and control the temperature of the electric oven in accordance with the temperature of the sun so that the printed Opak container does not melt or melt. This research will contribute to the development of science and technology in the field of Telecommunications Electronics and Information Technology. Furthermore, it can help effectively for Opak producer to increase Opak production without being affected by weather conditions or the drying area. Opak production can already be done both indoors and outdoors. Finally, consumer demand can be fulfilled.

1. Introduction
Home industries are part of the Micro, Small and Medium Enterprises (MSMEs) that contribute to increase the growth of Indonesia’s Gross Domestic Product (GDP). One example of this industry is the Opak’s industry located in Sukaraya Village, District of Pancur Batu, Deli Serdang Regency. Opak is a local snack that is produced from processed by cassava raw materials. Each MSMEs is able to process an average of 1.5 tons of Cassava to be Opak for single day. Opak is processed from cassava. It is still done in a simple way using human power starting from peeling, washing, steaming / boiling, kneading and drying, except flattening and printing are assisted by a machine. The printed opak is placed on top of the plastic media for the drying process. The drying process is done conventionally, relying only on sunlight radiation and requires a large area for the location of Opak drying. Problems arise when the weather is cloudy or rainy, so Opak production is threatened to fail because Opak becomes moist and mouldy so it cannot be marketed. Finally, Opak producer will suffer of losses.
To overcome of drying Opak problems, it can be done using an electric oven. Oven has been widely used to dry various types of food production such as fruit chips. However, the Opak drying process is different from the drying process of other products. Opak uses special plastic media to hold the Opak dough that has been printed before drying. So that the plastic media does not melt in the oven, the temperature and humidity of the oven must be equated with the temperature of sunlight radiation. Therefore, we need a system to detect and control the temperature and humidity of the oven to remain stable, so that the level of dryness of Opak which is dried by the oven will be the same or better quality when compared with conventional drying methods using solar radiation.

2. Literature Review

2.1. Smart Sensor

The term of “smart” is an adjective to describe someone who is smart and intelligent. In daily life the word “smart” can also be used to describe non-human abilities or objects that resemble human capabilities such as smart technology that can facilitate us in interacting, communicating, accelerating work processes, monitoring both at home and in the office. Thus, it can be said with smart technology that makes a comprehensive system, with fast and consistent reactions [2]. While the sensor is used to detect an object or environment in order to control or make measurements. The function of the sensor is to change the chemical quantities, light, heat, magnetic, mechanical and others into electrical quantities in the form of current, voltage and resistance [4]. Smart Sensor is a tool to detect automatically and in real time when measuring and controlling [5].

2.2. Temperature and Humidity Sensor

To detect the changes of temperature in an object or environment, you can use Temperature Sensors. This sensor serves to convert the amount of heat into electrical value [1]. Temperature sensors measure the temperature of heat or cold of an object so that we can know or detect changes in temperature on an object. The output received by the sensor is an analog signal or a digital signal [3]. Humidity sensors are usually used to measure water content contained in an object such as water content in the soil or food [6]. Example of a temperature sensor with Arduino Uno in Figure 1.

![Figure 1. Temperature Sensor and Arduino Uno](image)

DHT11 is one of the humidity sensor has a module that serves to detect the temperature and humidity of an object. The resulting output is a calibrated digital signal. Just like a temperature measuring device, this sensor module is included in the recessive element group. Compared to other sensors, the DHT11 sensor has an advantage in the process of detecting and reading data very well that is responsive and fast in detecting room conditions and not easily interfered [4].
2.3. Arduino Uno
The term of “Arduino Uno” is one of the boards of the Arduino family, which is a microcontroller development kit based on ATMEGA 28. There are several types of arduino boards such as Arduino Pro Mini, Arduino Yun, Arduino Nano, Arduino Mega and others. But the famous one is Arduino Uno. Arduino Uno R3 is the latest in the Arduino USB series [6].
To support the microcontroller work process, this module has been equipped with various features such as plug and play. Arduino Uno is ready to operate by connecting to power supply or a connection via a USB cable to a PC. Arduino Uno Board has 14 digital input and output pins, 6 analog input pins, one 16MHz ceramic resonator, USB connection, power connector, ICSP header, and one reset button [6].

3. Method

3.1. Parameters
Measured parameters are:
1. The temperature of sunlight when Opak drying is conventionally used as a standard reference.
2. Temperature of the Opak Dryer Oven.
3. Comparing of the dryness level using the temperature of sunlight with the temperature set using a drying oven.

3.2. Research Model
This research was conducted by applying a comparison algorithm to reach the level of sensor performance used in the Smart COpak system (placed in an electric oven). Electric ovens used have body dimensions of 45x31x34 cm and pan dimensions of 33x31x31 cm with capacities up to 13 L, electric power of 1050 watts equipped with 2 heating elements (upper and lower), made of stainless steel with a minimum temperature of 30 degrees Celsius and a maximum of 230 degrees Celsius.

3.3. Circuit Model
Circuit model is shown in Figure 2.
4. Results

4.1. Relay Testing
The relay circuit functions as a regulator of on or off for heating filament as set in the programming algorithm (software). This setting aims to adjust the temperature of the oven such as the temperature of the sun when it is sunny/hot (400°C). When the temperature inside the oven has exceeded 410°C, the relay will automatically deactivate the heater to avoid overheating which can cause opak plastic container to catch fire. Conversely, when the oven temperature is less than 390°C, the relay will reactivate automatically to keep the temperature in the oven stable, used to dry opak, with a faster duration of time than just relying on the temperature of the sun. The relay circuit test results are shown in Table 1.

| Temperature (°C) | Logic | Condition          |
|------------------|-------|--------------------|
| > 41             | 0     | Non active         |
| < 39             | 1     | Active             |

4.2. DHT 21 Sensor Testing
The DHT 21 sensor is an important component that is used to detect temperature and humidity in the opak drying oven. Sensor testing is done to find out how much the sensitivity of the sensor. By getting the actual value and the value of the measurement results, it will get an error in percentage. Table 2 is shows the test results of the DHT 21 sensor test against a comparison measuring instrument.

| Sampling | Thermometer (°C) | Sensor Output | % Error | Hygrometer (% RH) | Sensor Output | % Error |
|----------|------------------|---------------|---------|-------------------|---------------|---------|
| 1        | 28               | 31            | 10,71   | 59                | 49            | 16,95   |
| 2        | 28               | 31            | 10,71   | 59                | 49            | 16,95   |
| 3        | 28               | 28            | 0,00    | 59                | 59            | 0,00    |
| 4        | 28               | 28            | 0,00    | 59                | 55            | 6,78    |
| 5        | 28               | 28            | 0,00    | 59                | 54            | 8,47    |
| 6        | 28               | 28            | 0,00    | 59                | 54            | 8,47    |
| 7        | 28               | 28            | 0,00    | 57                | 54            | 5,26    |
| 8        | 28               | 26            | 7,14    | 57                | 55            | 3,51    |
| 9        | 29               | 26            | 10,34   | 57                | 56            | 1,75    |
| 10       | 29               | 27            | 6,90    | 56                | 55            | 1,79    |
| 11       | 29               | 27            | 6,90    | 57                | 55            | 3,51    |
| 12       | 29               | 26            | 10,34   | 57                | 56            | 1,75    |
| 13       | 29               | 27            | 6,90    | 57                | 55            | 3,51    |
| 14       | 29               | 27            | 6,90    | 61                | 55            | 9,84    |
| 15       | 29               | 26            | 10,34   | 60                | 58            | 3,33    |
| 16       | 29               | 28            | 3,45    | 60                | 57            | 5,00    |
| 17       | 28               | 28            | 0,00    | 59                | 56            | 5,08    |
| 18       | 28               | 28            | 0,00    | 59                | 56            | 5,08    |
| 19       | 28               | 28            | 0,00    | 59                | 56            | 5,08    |
Data retrieval took place for 150 minutes by taking data every 5 minutes and comparing directly with the Temperature Clock Humidity HTC-1 in which there is a thermometer and hygrometer and direct observations. Testing using water spinach plants. Seen in Table 2 the highest percentage of temperature error is 10.71% and the lowest is 0%, while the highest percentage of humidity error is 16.95% and the lowest is 0% with an average temperature error value of 4.21% and the value of the average humidity error is 5.44%. In the test results there are differences in the temperature and humidity values of DHT 21 with the HTC Humidity Temperature Clock HTC-1. The difference is due to the sensitivity and accuracy of each sensor is different. Basically, the change in the value of the DHT21 sensor and the comparison device in this case the HTC Clock Temperature Humidity HTC-1 is almost the same value even though there is a difference in the value of the error value in the experiment.

4.3. Testing of Opak Condition and Plastic Containers in The Oven
Plastic containers are very important components used after opak molding process and when opak drying. Testing of opak and plastic containers in the oven is carried out in a duration of 140 minutes for temperatures of 390°C to 520°C and duration of 100 minutes for temperatures > 600°C. Table 3 shows the results of the test for the condition of opak and plastic container inside the oven.

| No | Time (Minute) | Temperature (°C) | Humidity (%) | Opak Condition | Plastic Condition |
|----|---------------|------------------|--------------|----------------|------------------|
| 1  | 10            | 39               | 30           | wet            | good             |
| 2  | 20            | 40               | 30           | wet            | good             |
| 3  | 30            | 41               | 50           | wet            | good             |
| 4  | 40            | 42               | 20           | dry            | good             |
| 5  | 50            | 43               | 20           | dry            | good             |
| 6  | 60            | 44               | 20           | dry            | good             |
| 7  | 70            | 45               | 30           | dry            | good             |
| 8  | 80            | 46               | 20           | dry            | good             |
| 9  | 90            | 47               | 20           | dry            | good             |
| 10 | 100           | 48               | 25           | dry            | good             |
| 11 | 110           | 49               | 20           | dry            | good             |
| 12 | 120           | 50               | 20           | dry            | good             |
| 13 | 130           | 51               | 20           | dry            | good             |
| 14 | 140           | 52               | 20           | dry            | good             |

\[ \bar{X}_{\text{Error}} = 4.21 \]

\[ \text{Error} = 5.44 \]
As shown in Table 3, for temperatures of $39^\circ$ C to $52^\circ$ C, a decrease in the percentage of humidity in the oven occurs when the temperature rises, so that opak starts to dry and the plastic container remains in good condition. However, to increase the temperature $> 60^\circ$ C there is an instability in the percentage of moisture content in the oven, this is caused by the evaporation of air content when opak starts to burn and immediately caused by a burning plastic container.

5. Conclusion

The drying process is using an electric oven equipped with an automatic temperature detection and control system, which is called Smart COpak, is an effective method. This system will detect and control the temperature of the electric oven in accordance with the temperature of the sun so that the printed Opak container does not melt / melt. In this study, several testing stages were carried out, namely relay test testing, DHT sensor sensitivity testing 21, and testing the condition of opaque and plastic containers in an electric oven.

Based on the relay circuit test results obtained, the heater will be inactive (logic 0) when the temperature in the oven $> 41^\circ$ C. Conversely, when the temperature in the oven $< 39^\circ$ C, the status of the heating condition will be active (logic 1). For testing the sensitivity of the DHT 21 sensor, the highest percentage of temperature error is 10.71% and the lowest is 0%, while the highest percentage of humidity error is 16.95% and the lowest is 0% with an average temperature error value of 4.21% and the average humidity error value is 5.44%. And the last is the testing of the condition of opak and plastic containers in an electric oven, the results are, for temperatures of $39^\circ$ C to $52^\circ$ C, there is a decrease in the percentage of moisture content in the oven when the temperature rises, so the opak starts to dry and the plastic container remains in good condition.

For further study of this research, a conveyor belt device can be developed as an opak container by utilizing steam boilers sourced from gas fuel to dry the opaque. The goal is to increase opak production, efficient in use, time, energy, and cost.

6. Future Works

The process of opak drying is using an electric oven requires a large electric power consumption. This will have implications for increased expenses. Although rain no longer affects to opak production, but it must still consider the costs arising from the process. If it does not match the expenditure and income, in this case, the expenditure is greater than the income, then opak producer will actually suffer losses.

For the next stage, it is necessary to substitute energy use. For example, opak drying uses a gas-fired oven. With consideration, gas can produce perfect combustion and the cost is cheaper than using electricity.

7. References
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