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Design of a coffee bean dryer prototype based on the internet of things

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ABSTRACT

Coffee is one of the plants that is widely cultivated in tropical countries such as Indonesia. Coffee plantation commodities at least contribute a lot to the Indonesian economy, which creates foreign exchange, farmer income, industrial raw materials, employment, and regional development. This research aims to design coffee bean dryer equipment using a heater as a heating element instead of sunlight for the process of drying coffee beans. When the temperature has reached 60°C, the heater will turn off briefly, and if the set time has not expired, the heater will always be alive. If the humidity does not decrease, the fan will fail. In this research, using experimental research procedures where each measurement is used effectively by each sensor so that the measurement results of each sensor are accurate. From the test results, it can be concluded that the initial weight before drying was 1000 grams, while the weight after drying was 880 grams.

Keywords: Coffee; DHT22 sensor; IoT

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INTRODUCTION

Coffee is one of the plants that is widely cultivated in tropical countries such as Indonesia, a coffee plantation commodity that contributes greatly to the Indonesian economy, which creates foreign exchange, income for farmers, industrial raw materials, employment opportunities, and regional development [1-4]. To enjoy a cup of coffee, the coffee beans must be dried. This is generally done traditionally, by drying directly in the sun [5-7]. However, the weakness in terms of drying is that it is very dependent on the weather and requires quite a large space. Coffee beans also have to be raised when it is cloudy and when it rains. Because drying is postponed or cannot be done during the rainy season, production will automatically decrease. As a result, coffee beans require a lot of space and a long time for drying [8-12].

With the rapid growth of technology, activities continue to become easier to try. The internet of things (IoT) is an action carried out by using the internet or network as a tool to connect [13]. One of the benefits of the IoT is an application or website that can collect information such as temperature, humidity, drying time, and the condition of coffee beans to enable monitoring [3,14].

The concept of the IoT describes how objects are connected to the internet and can share information through connectivity. IoT refers to items that can be identified separately as virtual images in an internet-based structure, such as the ability to exchange information and remote control [15-17].

This research aims to create a prototype of an automatic coffee bean drying system that uses a DHT22 sensor to determine temperature and humidity, and a heater to heat the coffee beans during the drying process. It is hoped that this prototype will help coffee farmers in the process of determining. For this reason, the author chose the title prototype of IoT-based automatic coffee bean drying equipment that has temperature and humidity control. Drying coffee must be done at a temperature of between 50°C and 60°C because at this temperature the movement of water particles and evaporation take place well. Very high drying temperatures can cause damage to the surface of the beans (case hardening), make it difficult to move water particles in the beans, and cause the dried coffee beans to be less good. The relative humidity (RH) of coffee that is good for drying coffee is 39% – 56% [5].

LITERATURE REVIEW

Siti Nutyanti Afriani's study in 2019 was entitled Web Server Based Automatic Coffee Bean Drying System Prototype. According to research results, this system has the ability to open and close the roof according to weather conditions. In addition, if the drying chamber temperature changes and the air humidity or water vapor content is low in the drying chamber, this system will operate the lamp as an artificial dryer. By using a web server to control and monitor the system remotely, this system makes it easier for humans to dry the coffee beans [2].

This study was conducted by Asyiva Nurbaeti (2021) with the title development of IoT-based coffee bean drying equipment. The initial weight before curing was 250 grams and the weight after curing was 247 grams. This is caused by a decrease in water content in coffee beans. An average temperature of 49,750ºC and an average humidity of 46.8% can be measured by the DHT22 sensor. The process of drying data from the device to Google Firebase takes an average of 0.01 seconds or 10 milliseconds, which is a very good delay [11].

RESEARCH METHODS

The method used in this research is an experimental method where the coffee bean dryer uses a heater with IoT based temperature and humidity control, where this coffee bean dryer is capable of drying 1 kg of coffee beans at a temperature of 60ºC for 4 hours, and the dryness of the coffee beans is by SNI No. 01-2907-2008. There is an influence of temperature and holding time in the dryer on the moisture content of the coffee beans produced. The higher the temperature and holding time, the lower the water content of the coffee beans. This research requires several pieces of equipment, namely a multimeter, soldering iron, scissors, tin, screws, pliers, duct tape, and a screwdriver. On the other hand, the components used are DHT22, DC motor, 12 Volt 5A power supply, relay, dimer, heater, buzzer, RTC DS3231.

System Block Diagram Design

The preparation of this concept is logical thinking in achieving effective output aimed at producing sensor measurement data and a coffee heating system that is expected to run according to SNI. The design of the equipment block diagram in this research is shown in the following block diagram.

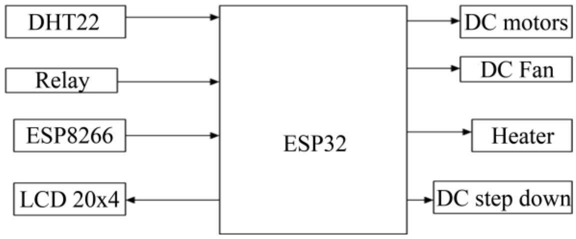

Figure 1. Design of the system block diagram.

In this research, a block diagram was designed using an ESP32 microcontroller which was used to connect the designed prototype. The ESP32 microcontroller was used as the microcontroller for the designed tool. In this research, 1 unit of ESP32 microcontroller was used. used as a dryer tube swivel. DHT22 is used as a temperature and humidity sensor, and LCD 20x4 is used to monitor sensor measurement results on the prototype. The 12 Volt 5A power supply is used as a voltage supplier or provides DC. The relay connects the heating element source to the electrical power source and is part of the ESP32 output. Dimers are used as speed regulators in DC motors. Tool terminal blocks act as connectors and isolate the electric current in the tool circuit. The heater is used as a heater. Bazzer as a sound indicator. RTC DS3231 as a timer.

Software System Design

In this research, a software system was designed using a flowchart as a diagram to determine the working system of the prototype. The flowchart can be seen in the image below (Figure 2).

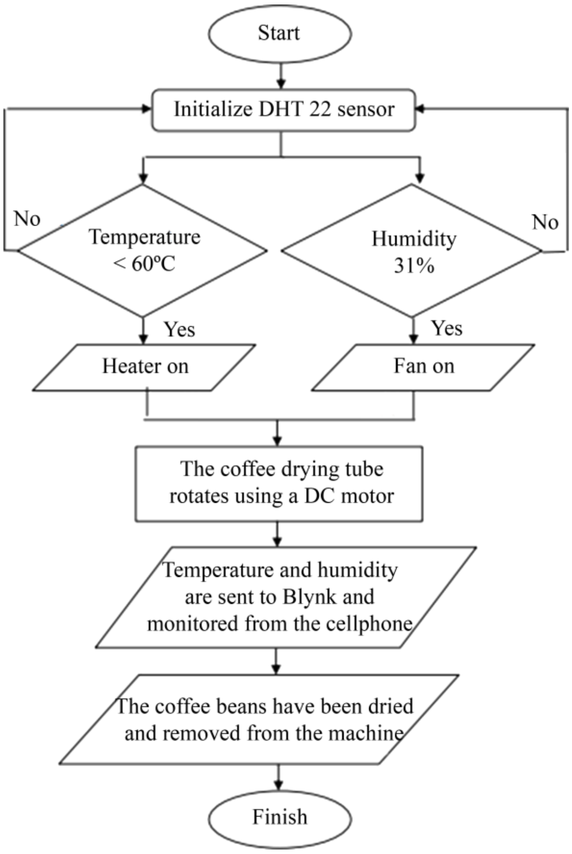

Figure 2. Design of a flow chart.

Test Design and Equipment Characteristics

The test design and equipment characteristics are made based on a prototype system which is used to determine the level of sensor accuracy and performance which aims to ensure that when the ON button is turned on, all components used in the compound box and coffee bean drying tube will be active, starting from the LCD screen which shows the temperature in the tube is measured by the DHT22 and the time is set by the RTC, then the heater that is on will produce heat in the coffee bean dryer tube. When the temperature in the tube has reached the desired high point, the heater will turn off and will come back on again when it has decreased. Then the buzzer will be active when the coffee bean dryer has been used at the time that has been set.

RESULTS AND DISCUSSION

DHT22 Sensor Testing

The DHT222 temperature sensor functions to detect the temperature in the coffee bean drying tube chamber. The DHT22 temperature sensor readings will be processed by the ESP32 and the output from the DHT22 sensor will control the heater via relay. This temperature sensor test is carried out to find out whether the sensor can work properly and correctly according to the plan that has been made.

To see the accuracy of the temperature reading, the DHT22 sensor temperature reading value is compared with the digital thermometer reading value in the same period. The temperature sensor comparison device is carried out using a digital thermometer. Test results of the DHT22 temperature sensor value by automatically measuring the thermometer visually.

Figure 3. Comparative testing of DHT22 and digital temperature.

Based on the data from the temperature measurement comparison results in Table 1, the initial temperature value (room temperature) was obtained at 36°C, with a time value of 10 minutes and humidity 58%, a time value of 20 minutes, namely a temperature of 41°C with a humidity of 45%, the time value 30 minutes is a temperature of 44°C with 39% humidity, a time value of 40 minutes is a temperature of 46°C with a humidity of 36%, a time value of 50 minutes is a temperature of 47°C with a humidity of 34%, a time value of 60 minutes is a temperature of 48°C with humidity 33%. a time value of 70 minutes is a temperature of

48°C with a humidity of 32%, a time value of 80 minutes is a temperature of 48°C with a humidity of 31%, a time value of 90 minutes is a temperature of 49°C with a humidity of 31%, a time value of 100 minutes is a temperature of 49°C with 31% humidity, a time value of 110 minutes, namely a temperature of 49°C with a humidity of 31%, a time value of 120 minutes, namely a temperature of 49°C with a humidity of 31%, so the average error value from the temperature measurement comparison data is 1.6%.

Table 1. Test results for DHT22 and digital temperature.

Time (minutes)	Digital temperature (ºC)	DHT22 (ºC)	Humidity (%)
10	37	36	58
20	44	41	45
30	46	44	39
40	47	46	36
50	48	47	34
60	49	48	33
70	49	48	32
80	49	48	31
90	48	49	31
100	48	49	31
110	49	49	31
120	49	49	31
Average	46.91	46.1	36

Relay Testing

In relay testing, the ESP32 functions to process the heater and fan data so that the relay can control the heater as a heat source. Based on the picture above, this test was carried out using ESP32 as a data processor that gives commands to the relay. The output on the relay will be connected directly to the heater and fan. relay test results with the DHT22 temperature sensor. When the temperature reaches a maximum temperature of 60°C, the heater will stop being active automatically and if the temperature is below 60°C, the heater will become active again. Testing the relay that is connected directly to the DHT22 temperature sensor can work well.

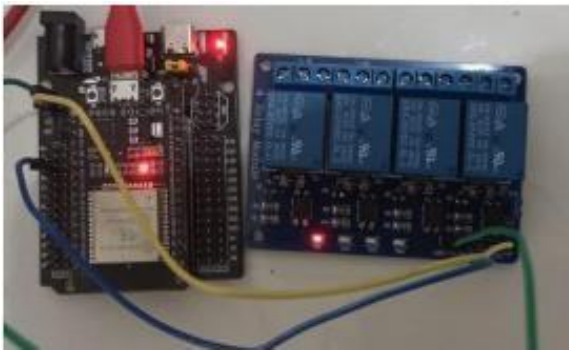

Figure 4. Relay testing.

Heater Testing

In this heater test, the PLN electricity flow that flows to the power supply and then to the heater will produce heat which will spread in the dryer tube and when the reference temperature that has been set has exceeded the reference temperature limit, the heater will turn off and the heater will turn on when the temperature is below 60°C. Here is the DC voltage. If the relay is active, the heater will be active given a voltage of 220 V. And if the voltage is 0 V, the heater will not be active. The heater will turn on when the temperature and time buttons have been set, such as setting a temperature of 60°C and a time of 4 hours, then the heater will turn on and the heat coming out of the heater will spread in the tube which will dry the coffee beans in the tube. The heater will turn off briefly when the temperature exceeds the maximum limit of 60°C from the set temperature and will turn back on when the temperature is below 60°C, and the heater will turn off automatically when the time set on the RTC has finished.

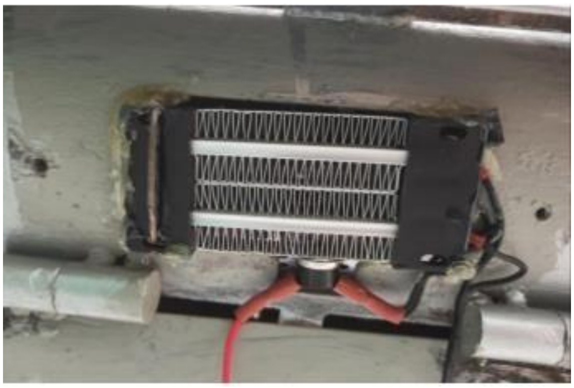

Figure 5. Heater testing.

Blynk Testing

Blynk is a platform for Android applications that aims to control ESP32 modules and similar modules via the internet. This application is used to control hardware devices and display sensor data. The way the Blynk application works is that first install the application, then open the Blynk application on Android, then create the sensors that you want to display and test, they will appear as in the image below.

Figure 6. Blynk application testing.

The results of the coffee bean dryer using 1 kg of coffee beans or the equivalent of 1000 grams require a drying time of 4 hours at a temperature of 60°C with a coffee bean weight of 880 grams. This test requires knowing what percentage of water content is contained in the coffee beans called wet base water content and before drying called dry base water content using a formula.

Where Bk (final weight) while Ba (water weight), Bk is the final weight after drying which was tested using 1000 grams of coffee beans, Bk was obtained at 880 grams while Ba (water weight) was obtained by reducing the initial weight of the coffee beans before drying with Final weight of coffee beans after drying. Ba = 1000 – 880 = 120 grams. So to find out the percentage of dry water content, here is the calculation:

$$\text{Content (\%)} = (\text{In. w} - \text{Fin. w}) / \text{In. w} \times 100\%$$
$$= ((1000 - 880) / 1000) \times 100\%$$
$$= 12\%$$

So it can be concluded that the water content in coffee beans after drying the water content in coffee beans is 12%.

Table 2. Condition of coffee beans in the drying tube.

Time (hours)	Temperature (°C)	Weight (grams)	Coffe Condition
0	28	1000	Wet
1	60	925	Humid
2	60	918	Half dry
3	60	898	Half dry
4	60	880	Dry

CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that the coffee bean dryer uses a heater with IoT based temperature and humidity control, where this coffee bean dryer is capable of drying 1 kg of coffee beans at a temperature of 60°C for 4 hours, and the dryness of the coffee beans is by SNI No. 01-2907-2008. There is an influence of temperature and holding time in the dryer on the water content of the coffee beans produced. The higher the temperature and holding time, the lower the water content of the coffee beans. When the ON button is turned on, all components used in the compound box and coffee bean drying tube will be active, starting from the LCD screen which displays the temperature in the tube as measured by the DHT22 and the time set by the RTC, then the heater which is on will produce heat in the tube coffee bean dryer. When the temperature in the tube has reached the desired high point, the heater will turn off and will come back on again when it has decreased. Then the buzzer will be active when the coffee bean dryer has been used at the time that has been set.

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