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Optimization of Herbal Dryer System Based on Smart Fuzzy and Internet of Thing (IOT)

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ABSTRACT

The herbal medicine industry is currently growing rapidly with increasing public interest in herbal medicine in Indonesia. Medicinal plant dryers have been developed but are still using conventional methods. Proper drying method is very influential on the content of active ingredients found in plants. Each type of plant has a different response, there are some plants that are sensitive to direct sunlight and temperatures that are too high and some are not. This research will take part in producing an adaptive medicinal plant dryer product with the help of a microcontroller that will be used for the herbal medicine industry. In addition, with an intelligent system based on the Internet of Thing (IoT), this tool can be monitored and controlled remotely so that it can make it easier for users to know the current conditions of herbs that are being dried in order to get effective and efficient drying results. This research is expected to improve the quality of medicinal plants in accordance with the needs of the herbal medicine industry to produce good quality drugs according to the standards of Good Manufacturing Practices (GMP).

Keywords: Natural resources, Internet of Things (IoT), smart temperature control, fuzzy PID, Herbal Dryer system

1. INTRODUCTION

Utilization of natural resources into herbal medicines in Indonesia is still small because the supporting facilities to develop medicinal plants into phytopharmaca are still lacking. The lack of techniques for handling post-harvest medicinal plants such as sorting, washing, draining, chopping, drying and processing to become various kinds of pharmaceutical products is a problem in itself. From these handling techniques, drying technique is a very important technique in producing quality simplicia [1]. Based on the above problem, this research will take part in the development of supporting facilities for processing various medicinal plants. The drying system of medicinal plants is one of the important focuses in this research because one of the steps that can be taken to improve the quality of herbal medicines is to improve the drying system. The existing natural drying system requires quite a long time to reduce the water content in medicinal plants because it only relies on sunlight as an energy source in the drying process. Changing day and night as well as the weather that changes throughout the year become its own constraints in the traditional drying system. In the rainy season, the water content in medicinal plants can increase so that these plants have the potential to become fungi growing media, in addition to the drying process carried out in an open space where medicinal plants are exposed to direct sunlight can cause these medicinal plants to be too dry so that they produce low quality products and require high energy.

Another focus in this research is the use of an intelligent system based on the Internet of Things (IoT) and the use of renewable energy as a power supply for dryer products. The form of development carried out is to design a microcontroller-based automatic dryer with a load supply sourced from a combination of direct sunlight energy and solar panels and can be monitored and controlled remotely. Variables monitored include temperature in the drying cabinet room, heating on / off status and heat dissipation, power generated by solar panels and power used by the system. The intelligent system in this study will use fuzzy logic and PID methods to produce optimal heat control so that the power used to heat the cabinet space becomes more effective and efficient. The load supply for this tool is sourced from a combination of direct sunlight energy and solar panels.

Solar panels are the most important component of a solar power plant (PLTS). The use of solar panels in this study aims to utilize sunlight that is always available throughout the year as a renewable energy source. Indonesia's position in the equator produces sunlight intensity of 4.8 kW / m2, so it is promising if it is used as a source of electricity in the dryer product that will be developed.

A. Literature Review

Simplisia is a natural material used as traditional medicine that has not undergone any processing unless it has been stated otherwise that is a dried material. Drying is one way to preserve postharvest products from medicinal plants because it can improve the quality of the resulting simplicia. Natural / conventional drying, which uses direct sunlight. The initial stage of the drying process is the rapid evaporation of water in the physical bonds of water [1]. The selection of the right drying process can produce simplicia according to the quality standards set by the government and can contain active ingredients, colors, and high secondary metabolites.

According to the Regulation of the Head of the Republic of Indonesia Drug and Food Control Agency No. 12 of 2014 concerning Quality Requirements for Traditional Medicines, simplicia is dried natural material that is used for treatment and has not been processed, unless stated otherwise the drying temperature is not more than 60oC. In general the requirements for water content of simplicia in medicinal plants are ≤ 10%. Based on the Regulation of the Head of the Republic of Indonesia Drug and Food Supervisory Agency Number HK.00.05.4.1380 concerning Guidelines on How to Make Good Traditional Medicines, every simplicia before use should be sorted to free from foreign material and other impurities. Then washed with clean water in the right way so that simplicia is free from microbial and other pollution. After being washed, it should be dried first in an appropriate manner so that there is no change in quality and reach the required water content, then clean and dry simplicia, and raw materials that are not simplicia that have passed the quality inspection if not used immediately should be stored in containers that have been corresponding. Considering the importance of implementing good laboratory practice, in this study we made an IoT-based dryer [2]. Solar panels are devices used to convert direct sunlight energy into electrical energy either directly by using photovoltaic (PV) or indirectly by using concentrated solar power to produce electrical energy. Solar panels work by passing the photoelectric effect on semi-conductor materials so they can create electricity when the sun shines on it. Photovoltaics are generally more environmentally friendly, do not produce noise or chemical pollutants during their use [3]. Sunlight emits waves with different wavelengths (250-2500 nm) from ultraviolet, infrared to visible light. Therefore solar panels have absorbers that are able to absorb as much solar radiation as possible and convert it into electrical energy. The process of absorption of sunlight by solar cells can be seen in Figure 1. Sunlight consisting of photons will hit the surface (absorber) of solar panels. From the absorber, the light will be reflected and passed, where the electrons are released from their bonds by a photon with a certain energy level, then an electric current flows.

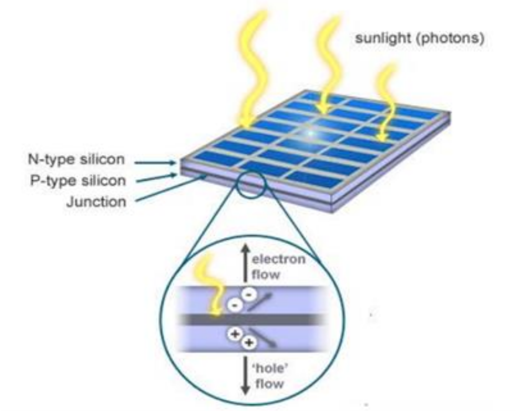

Figure 1. Solar Panel Material

The temperature sensor that will be used in this paper is the DHT11 sensor. DHT11 is a sensor that can measure two parameters at once, namely temperature and humidity. In this sensor, there is a thermistor Negative Temperature Coefficient (NTC) for measuring temperature, a resisitive *t*ype humidity sensor and an 8-bit microcontroller that processes the two sensors and sends the results to the output pins with a single-way cable format [4].

The DHT11 sensor is very easy to use with Arduino Uno, has a very good level of stability and has a very accurate calibration feature. The calibration coefficient is stored in the OTP memory program, so that when an internal sensor detects something, this module includes the coefficient in its calculation. The physical form of the DHT11 sensor is shown in Figure 2 [5].

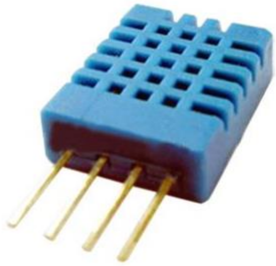

Figure 2. DHT-11 Sensor

Arduino Uno is a microcontroller based platform. This platform was created to simplify the process of circuitry and microcontroller programming so that it becomes easier to learn. This platform is compiled on a software called Arduino IDE. This software will help bridge between machine languages that are so complex that they become language and logic that are easier for humans to understand. Arduino IDE software itself can be downloaded for free on the official Arduino website and is available for various operating systems such as Windows, Mac OSX and Linux. The main purpose of this software is to help users to program the microcontroller in accordance with the specified task [6].

On the Arduino Uno platform, the popular microcontroller chip used is ATmega328. The ATmega328 microcontroller itself will act as a regulator of other components such as sensors, leds or motors connected to it. ATmega328 is an 8-bit microcontroller chip based on AVR-RISC made by Atmel. This chip has 32 KB of ISP flash memory with read-write capability, 1 KB EEPROM, and 2 KB SRAM. From its Flash memory capacity of 32 KB, this chip is named ATmega328. Other chips that have 8 KB of memory are named ATmega8, and ATmega16 for those that have 16 KB of memory [7].

Internet of Things (IoT) is an ongoing internet development where objects have communication capabilities that make them able to send and receive data. This device is able to provide real time data information. So that when things happen that are not expected, can be resolved quickly by the user. In this study, research will be conducted using the Raspberry Pi as a microprocessor that regulates all processes to be carried out [4].

2. METODOLOGY

The drying cabinet that has been built has a dimension of length 60 cm, width 50 cm and height 120 cm while the heat collector himself is designed with a length of 100 cm, width 50 cm and height 20 cm. Figure 3 is a side view of the drying cabinet and heat collector.

Figure 3. Cabinnet Dryer

The drying cabinet that has been built has three shelves with a gap between 20 cm as shown in Figure 4. In the picture we can see that there is one air vent above the door and two at the bottom that work together with the exhaust fan in removing the excess heat generated by direct solar heat. The two exhaust fans will remove excess heat from the cabinet if the resulting temperature exceeds a predetermined temperature.

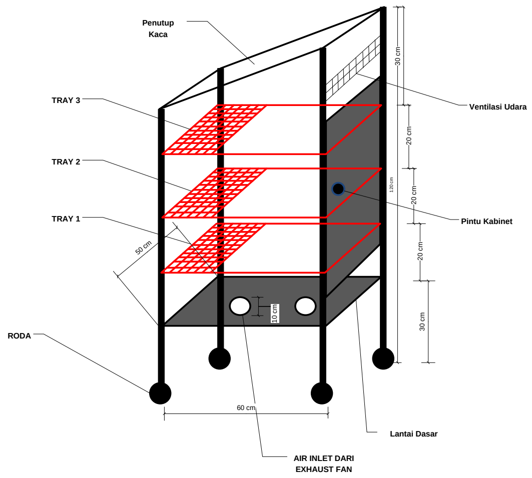

Figure 4. Drying Cabinnet Design

In this study, the system used is illustrated by Figure 4, from this picture it can be seen that the dryer of this medicinal plant will work at a temperature determined by the user with the help of a potentiometer. The temperature inside the drying cabinet will be read by the DHT11 sensor which will then be displayed by a 16x2 Liquid Crystal Display (LCD). The temperature value will be entered for the microcontroller. If the temperature value generated from direct sunlight is less than the predetermined value, the microcontroller will activate the heater with the help of solid state relay whereas if the temperature value generated from direct sunlight is more than the specified then the microcontroller will activate the exhaust fan.

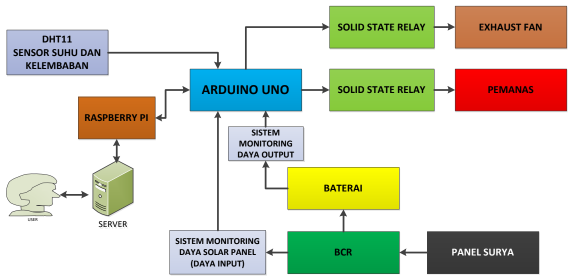

Figure 5. Diagram Block of Herbal dryer System IoT Based

To monitor the drying system, a website-based application that can be opened either on a smart phone or a desktop computer is made using the PHP, HTML and Javascript programming languages. This application will display information in the form of drying chamber temperature graph, heater status, exhaust fan status, graphs of power usage by the system, and the power generated by solar panels. The web app display plan will be created as shown in the following image:

The control method used in this study is Fuzzy PID, where Fuzzy logic functions to improve the performance of the PID control system by tuning the PID gain. The mathematical equation for PID control that will be used in this study as stated on Equation 1

$$PID_{output} = K_p e + K_d \frac{de}{dt} + K_i \int e \quad dt \quad (1)$$

Meanwhile, to control the heater, where the heater is activated by an on / off relay, it is necessary to adjust the time on and off the relay, setting the on / off time is stated by the following equation:

$$SSR_{on\_time} = PID_{interval} * PID_{output} \quad (2)$$

Table 1. Fuzzy function for tuning the gain of Proportional Constants (Kp)

e\de	B	S	Z	NS	NB
B	S	S	S	S	S
S	B	B	S	B	B
Z	B	B	B	B	B
NS	B	B	S	B	B
NB	S	S	S	S	S

Table 2. Fuzzy function for tuning the gain of the Derivative Constant (Kd)

e\de	B	S	Z	NS	NB
B	S	B	B	B	S
S	S	S	B	S	S
Z	S	S	S	S	S
NS	S	S	B	S	S
NB	S	B	B	B	S

$$\mu = \max(\mu, \min(e, de)) \quad (3)$$

Defuzification is the stage at which a decision taken by a fuzzy table is converted to a specified value as in the following equation:

$$Kp, d, i_f = \frac{\sum_{n=i}^{i=2} \eta_i . \mu_i}{\sum_{n=i} \mu_i} \quad (4)$$

To do the tuning, the following equation is used:

$$Kp = Kp_{min} + (Kp_{max} - Kp_{min})\, Kp_f$$
$$Kd = Kd_{min} + (Kd_{max} - Kd_{min})\, Kd_f \quad (5)$$
$$Ki = Ki_{min} + (Ki_{max} - Ki_{min})\, Ki_f$$

Control system block diagram as shown on the figure 6.

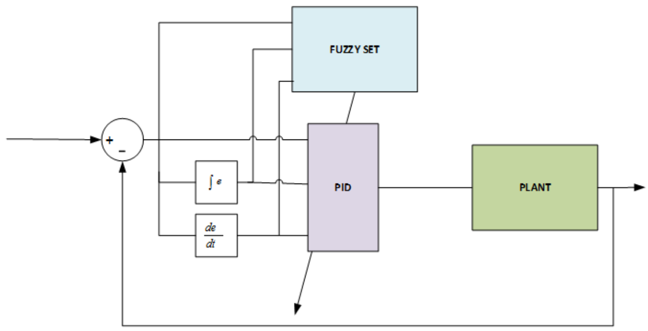

Figure 6. Smart Herbal Dryer Control System Block diagram

3. Result And Discussion

The implementation of temperature control was monitored using Internet of things and send to the website that was built by using PHP based codeigniter. Internet of things protocol used in this paper was http.protocol to update the data to be monitored in web by accsess the following url :

http://www.ourdomain.com/up.php?temp=value

the value received by web was processed to be stored in mysql database. The Internet of things web interface was shown in Figure 7 and 8.

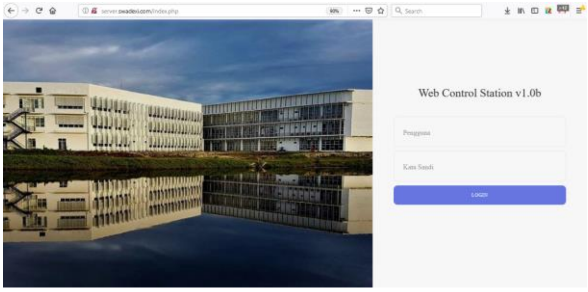

Figure 7. The Login page of IoT website Interface

Figure 8. The Monitoring page of IoT web Interface

Setpoint of temperature was set to 55˚C. The Implementation result that using smart Fuzzy PID and monitored using Internet of thing was shown in Figure 9 and 10.

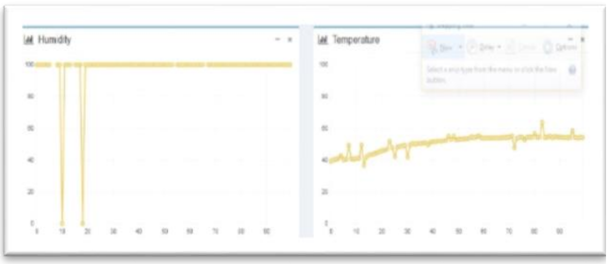

Figure 9. Implementation Result on Tracking setpoint

The results Figure 9, the right side of the graph shows the process of temperature tracking response from start temperature at 32˚C, the ripples on the graph was noises that present on temperature sensor. From the graph shows that when tracking, the temperature was not overshoot. The left side of the graph was the hummidity sensor that shows the level of drought of simplicia control room.

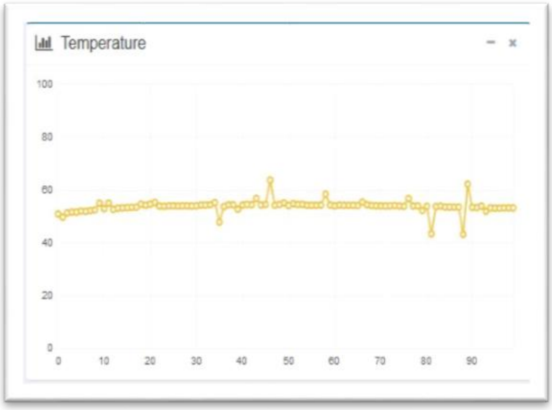

Figure 10. Implementation Result on steady state

On figure 10 shows the steady state of temperature control. From the figure shows that the controller was able to keep the temperature to be stable at setpoint condition.

4. Conclusions

From the implementation results it was shown that fuzzy smart PID controller performance was able to control the temperature to setpoint or target temperature without overshoot. The overshoot was also not present while tracking the temperature. But the temperature noise, must be eliminated or filtered using kalman filter so that the graph obtained had been better results.

Acknowledgement

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