Development of Temperature Controlling System in drying chamber by mixing air inlet

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Abstract

This research was to develop a temperature controlling system in solar chamber, using the flat-plate solar collector together with the working of blower with damper and heater to control the temperature. The microcontroller was used to process data: the temperature in the chamber and the temperature of the hot air and cold air at inlet ports, and then controlled the damper to optimize the air mixture at a constant speed of blower. This experiment used two identical chambers to compare the results from 3 systems: a chamber without controller, a chamber with PID controller, and a chamber with a basic controller, damper and heater. The results showed that the system with heater and damper could control temperature at 42 ºC. The chamber without controller had unstable temperature between 35 to 55 ºC. In addition, the temperature in the chamber with PID controller varied depending on the weather. However, the system with damper had the lowest power consumption.

Keywords: Drying solar chamber, Temperature controlling system, Microcontroller

Introduction

There are several types of agricultural products in Thailand. Fruits are one among the others of agricultural products. Some types of fruits grow dependently on season (e.g., longan) but some grow throughout the year (e.g., banana). In addition, many types of fresh fruits cannot be kept for a long time. Therefore, there are many people tried to develop techniques to preserve those agricultural products, especially fruits, such as drying, syruping. We founded that drying is the easiest and cheapest way to preserve products but there are still issues of an uncertainty in sunlight intensity, the problem with dust, insects, etc.[1]

These problems lead us to use drying solar chamber, which can prevent the problem discussed above. However, the drying solar chamber in the present day cannot control temperature as needed.[2] In this research, we develop the chamber in which the temperature can be controlled. The system is integrated by 3 parts: flat-plate solar collectors, chamber and controller. We also install a heater to heat input air temperature when that solar collectors cannot collect enough power from sunlight. We also apply the mixture of cool air from ambient to cool down the air from solar collector when its temperature is too high. We use the constant speed blower.

Experimental Design

Solar Chamber

The components of the solar chamber are as follows.

- Solar collectors: a flat plate V-shaped with a 3x1 square meters, covered with a glass thickness of 5 mm.[3,4]
- Two chambers covered with galvanized sheet with 0.5x0.70x0.75 cubic meters. They are side-by-side assembled together but can work independently.

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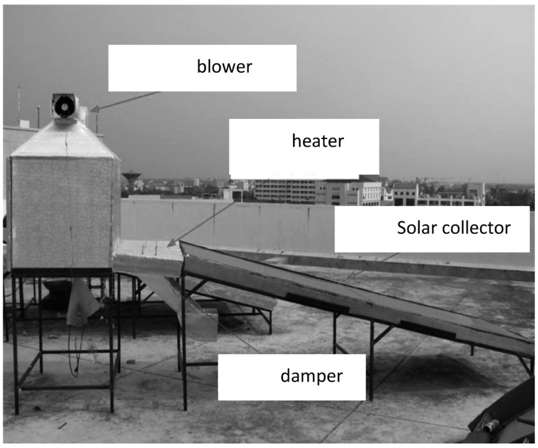

Figure 1 Solar chamber components

- Damper powered by 6-volt servo motor with 1500-watt heater installed in the front of damper to provide additional heat when necessary.
- Blower with 12-cm diameter and use 12V DC power. It was setup to work at a constant speed, 80% of maximum speed.
- Controller made up from AVR ATmega168 microcontroller and ds1820 temperature sensor, to facilitate software development and cable wiring.[5]

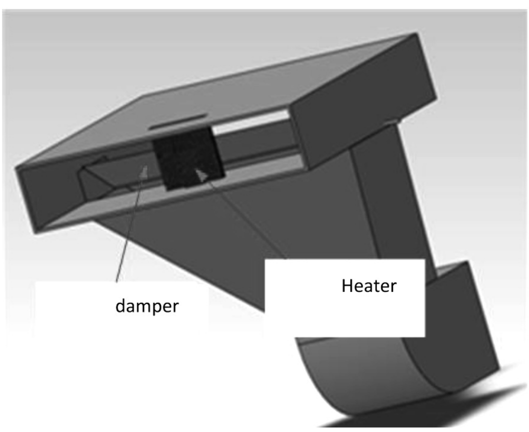

Figure 2 Damper and heater installed position

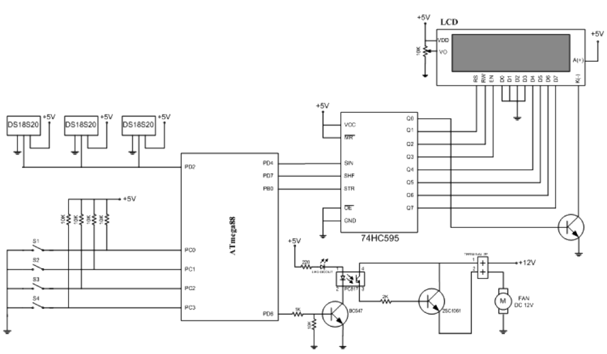

Figure 3 Microcontroller circuit in the controller

The experiment was designed to use two identical chambers to compare the results from the three systems: the control system with damper and heater, the chamber without a temperature control system but using a constant speed blower, and the temperature control system with PID control[6,7] by controlling the temperature at 42 ºC. We use data logger to record the temperatures at various points as shown in Figure 4 and record power consumption of the system every 15 minutes interval.

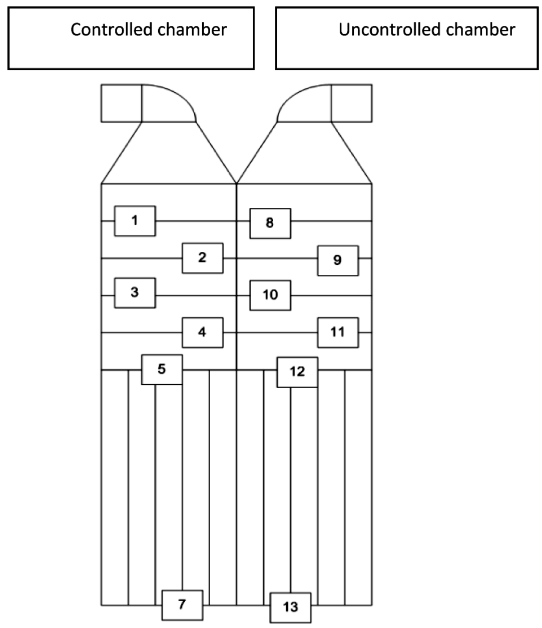

Figure 4 Thermo-couple installed position

The controller software

The controlling software is an important part of the temperature control system in the chamber in which control all hardware in the system. The overall process is shown in figure 5.

In our experiments, the software controls the blower to run at 80 percent of maximum speed. Then, it will read the temperatures from sensors in the chamber and average them. If the temperature in the chamber is not equal to the set-point temperature, the controller will adjust the angle of the damper to change the mixture proportion of hot-air and cold air.

In the case of without enough sunlight, the hot air temperature is not high enough and is lower than the set-point temperature. The software will automatically run the heater.

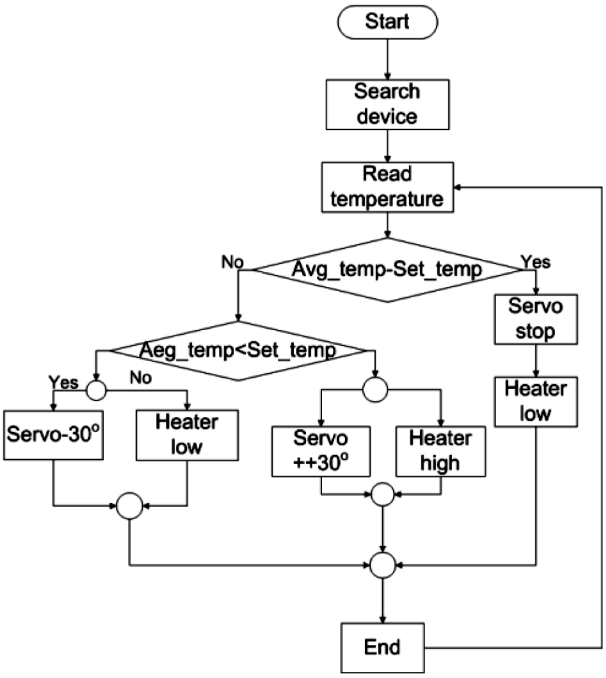

Figure 5 Software flowchart

Results and discussions

From the experiment with 42 °C set-point temperature, we have the results as shown in graphs in figure 6 to figure 8 indicating an average temperature in chamber and time.

We also found that the temperature in the chamber with damper and heater approached 42 °C with less than 1 °C error as shown in figure 6. This is a result of the system which can automatically adjust the inlet air mixer. The heater can increase temperature as needed. However, there is an approximately 1 °C error left because the system does not have any control condition in the controller.

For the system without temperature control system, the temperature varies between 35-55 °C. The system with PID controller also has the same results. This is because the blower is too small for the system and the ambient temperature changes continuously depending upon the weather variation.

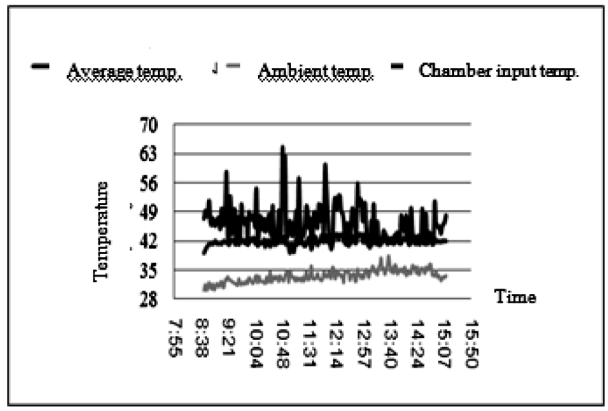

Figure 6 Temperature in the chamber with damper and heater

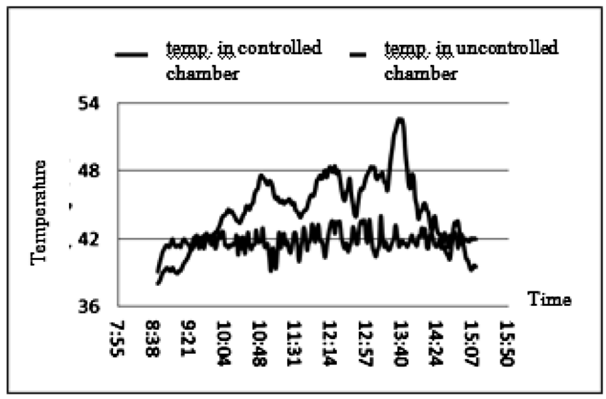

Figure 7 Comparing temperature in the chamber with damper and heater and uncontrolled chamber

By comparing the results between the chamber with controller and damper and the chamber with PID control system as shown in figure 8, we find the differences in these results. The weather during 10:00 to 12:00 can be easily predicted that it rains. The temperature in the chamber with PID controller is always lower than the set-point temperature. Also, during 13:00 to 15:00, it is sunny. The temperature in the chamber with PID controller is always higher than the set-point temperature because the air leaving from solar collector is too hot. The blower cannot blow hot air off to make the temperature in-range. Unlike the chamber with damper and heater, it can control temperature better because the heater raises the temperature as needed during 10:00 to 12:00 and the damper changes an air mixture to increase cold air during 13:00 to 15:00 to make the temperature in the chamber more stable.

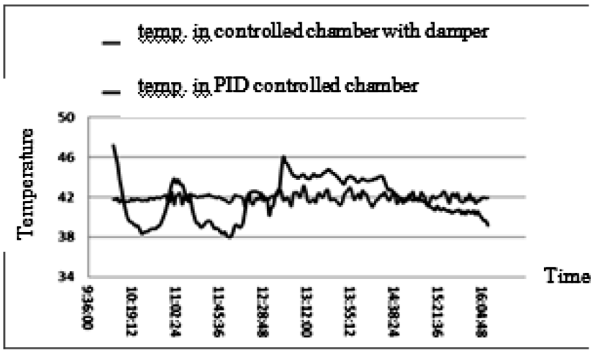

Figure 8 Comparing temperature in the chamber with damper and heater and the chamber with PID controller

When comparing the energy consumption of the chamber with damper but without heater and the chamber with PID controller, we found that they consume the same level of power with only a little bit different. The main reason of this comes from the blower in the chamber with damper which works at a constant speed while the blower in the chamber with PID controller can reduce speed for efficient power consumption.

However, when using the heater with the damper, we found that when the heater is working, it will consume much more power than the chamber with PID controller.

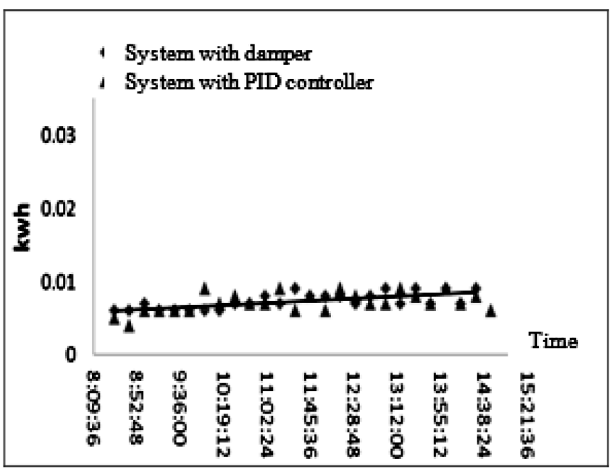

Figure 9 power consumption in chamber

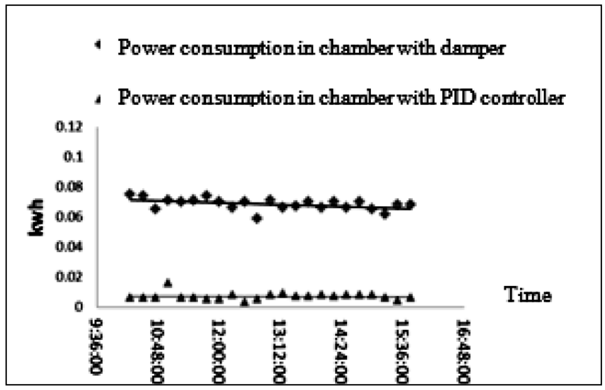

Figure 10 Comparing power consumption every 15 minutes interval

Conclusion

The controller with damper and heater can control the temperature in the range of 42°C with the error of less than 1 °C. If we compare the results with the other system, the system without temperature controller has the temperature between 35 to 55 °C. The temperature in the chamber with PID controller has the temperature in the same range as the uncontrolled chamber. However, when comparing the energy consumption, the system with the heater consumes power the most. In contrast to the same system without the heater, it consumes power the least but it may cause a problem when there is an absence of sunlight for a long period.

In addition, if we develop the better software to control blower, it will be able to adjust its speed as the one used in the chamber with PID Controller. More energy will be saved.

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