Modeling and Simulation on Temperature Control System of Farm Products Baking Equipment

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***Abstract*-In order to design a kind of temperature control system of the equipment used for baking farm products. The main function of the system is controlling the temperature in the baking room, ensuring it varies with the technological requirement. First, establish the system state equation based on the Fourier's Law. Then, set up the parameters such as the norms of the baking house, the thermal resistance of the wall and the air velocity in the baking house. As the model was established, input the technological temperature cure. The response curve shows that this system could satisfy the requirement of the process technology.**

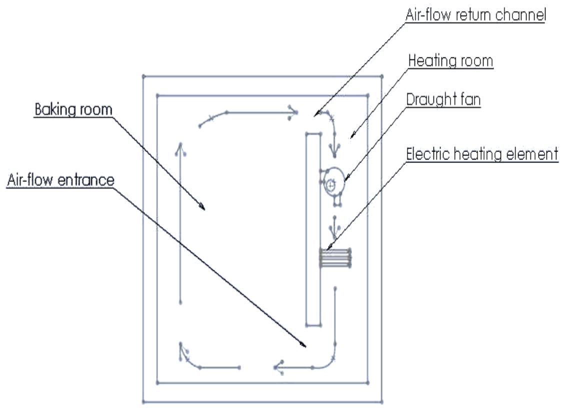
***Keywords*-Simulation; Temperature Control; Baking Equipment**

I. INTRODUCTION

Baking process is an important mean to efficiently convert the agricultural products into finished products in quantity and increase the additional value of it[1]. The most important model of the baking equipment is the temperature control system, which must make the temperature condition in the baking house meet the requirement of the process technology. Lots of papers have studied the temperature control system in many fields [2-5], however, papers about baking house for agricultural products were seldom seen. Therefore, in order to control the temperature in the baking house more accurately, more attention should be concentrated on the temperature control system.

II. MODEL BUILDING

As Picture 1 shows, the baking equipment could be divided into two main sections, the heating-room and the baking room. The former is equipped with a draught fan and a electric heating element which can make hot air-flow from the heating-room to the baking room. The latter, the main body of the equipment, is used for containing the agriculture products prepared for baking. Between the two sections, there are the air-flow entrance and the air-flow return channel, through which, the hot air could flow from one section to another constantly. Hence, the so called hot air-flow recycle [6]is formed.



Picture 1 The general structure of the baking equipment

When the equipment was started, the control element would compare the temperature signal received from the sensor which indicating the real temperature in the baking house with the setting value of the technological curve. If the real temperature is higher than the setting temperature, the draught fan and the heating element will be turned on, so there will be hot air-flow in the baking room; else, the heating element will be turned off. Therefore, the temperature in the baking room will be kept in a relative constant level which is decided by the technological curve.

A. Establishment of the Heater model

The heater was composed of the electric heating element and the draught fan. Suppose that the working temperature of the heating element and the velocity of the air-flow formed by the fan were both constant so that the model would be simplified. Here is the state equation[7]:

$$\frac{dQ}{dt} = (T_{heater} - T_{house}) \cdot M \cdot c$$

$\frac{dQ}{dt}$ = *heat flow from the heater*

c = heat capacity of air at constant pressure

M = air mass flow rate through heater(kg/h)

T_{heater} = temperature of hot air from heater

T_{room} = *current room air temperature*

The equation indicates that the heat flow from the heater is decided by three elements, the heat capacity of air constant pressure, the air mass flow rate dimensioned in *kg/h* from the heater and the difference of the temperature between the the air from the heater and the air in the room.

B. Establishment of the Baking room model

The Baking room model was designed to reflect the temperature varying condition in the baking room. Two main elements were concerned by the model: the thermal energy acquired from the heater and the energy exhausted in the process of baking the agricultural products. This is the state equation [8]:

$$\left(\frac{dQ}{dt}\right)_{losses} = \frac{T_{room} - T_{out}}{R_{eq}}$$

$$\frac{dT_{room}}{dt} = \frac{1}{M \cdot c} \cdot \left(\frac{dQ_{heater}}{dt} - \frac{dQ_{losses}}{dt}\right)$$

$$M = mass\ of\ air\ inside\ the\ house$$

$$R_{eq} = equivalent\ themal\ resistace\ of\ the\ house$$

In the process of producing, the heat of the inner air was acquired from the heater and lost to the environment. Thus, the velocity of the temperature in the baking room is mainly decided by the differential value between the rapid of getting and losing energy.

C. Establishment of the whole model

The Baking room model was designed to reflect the temperature varying condition in the baking room. Two main elements were concerned by the model: the thermal energy acquired from the heater and the energy exhausted in the process of baking the agricultural products. This is the state equation [8]: The integrated model was founded on the base of Simulink. First, drag the modules into the new founded model. Then input the parameters or transfer functions to the modules. Last, link the modules like below:

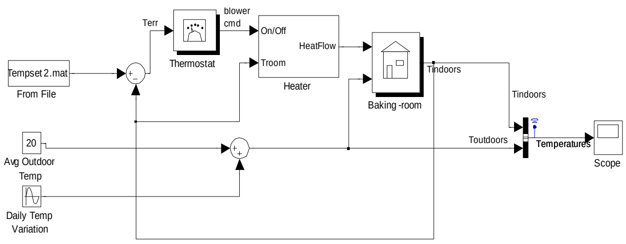


Figure 1.The baking room model

This system of a closed loop could be separated into three parts except the inputs and the output: the controller, the performer and the object. There are three inputs in the system. The Tempset module represented the technological temperature curve decided by the category of the farm product. The Avg Outdoor Temp module was set on a constant value:20℃ which was supposed to be the average temperature of outdoor. The Daily Temp Variation module was actually a sine curve , the term of which was 24 hour, the same as the natural condition. The Avg Outdoor Temp and the Daily Temp Variation was summed to represent the environmental temperature variation. The Thermalstat module performed the function of controller. It can decide whether the heater should be turned on or off. The heater is the performer which can blow hot air into the baking room when it was turned on. As a result , the temperature in the baking room can be adapted to a relative constant level as we expected.

III. SIMULATION

The temperature curve of a certain farm product is indicated as figure 2. Apparently, the temperature curve can be divided into three steps. The first step is very cliffy, which means that the temperature develops very quickly. The second step of the curve shows that the developing velocity of the temperature is slow down. In the third step, the temperature goes directly to the max value.

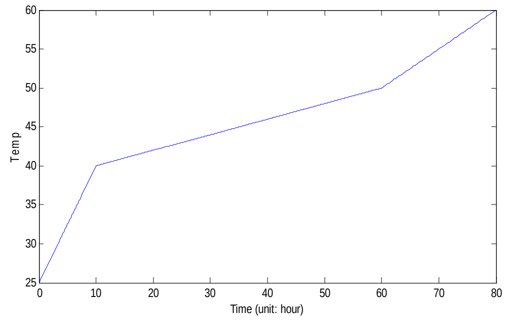


Figure2. The inputted temperature curve

Running the system, a response temperature curve (the yellow line) will be seen as figure 3, which indicates that the response temperature curve has generally reflected the trend of the inputted curve (figure 2) and the movement of the up-and-down wave which means the adaption of the heater caused by the environmental varying temperature curve (the violet line).

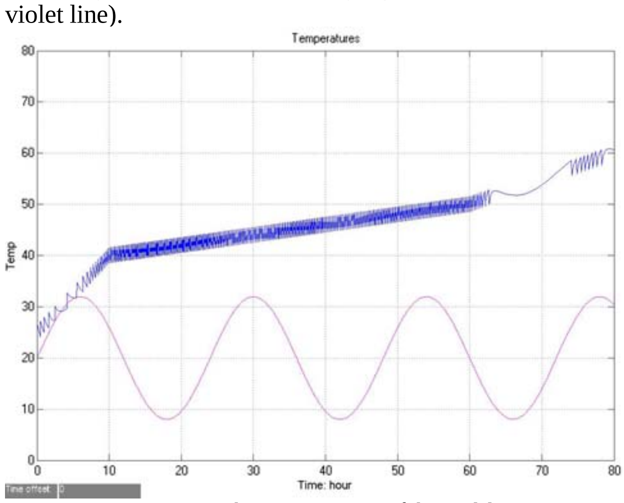


Figure3. The response curve of the model

For the reason of having a relative short time span, figure 4 shows more clearly in detail than Figure 3 as a section of it. When the model was started, the temperature in the baking room went quickly from 20℃to about 26.8℃, near 25℃, the setting value of the starting time, which proofs that the response time is very short and the exceeding value is less than 2℃.Through the whole term, the respond temperature is waving around the setting value constantly.

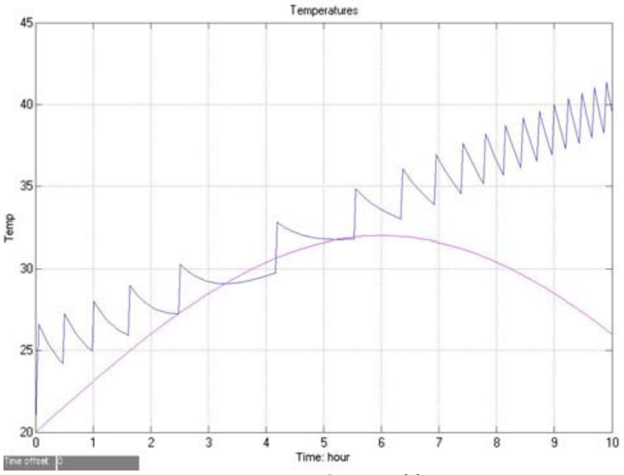


Figure 4. A sectional curve of figure 3

IV. CONCLUSION

Since the requirements in the process of agriculture products are relative rough [9], the accuracy of the system is completely comfortable with the requirements. Therefore, a conclusion could be got that this temperature control system is qualified for the baking equipment of the agriculture products. In consideration of other factors such as the different properties of various farm products and the uncertainty of the environment temperature, there is still large space to improve the system. Meanwhile, much more efforts should be expend on perfecting the temperature control system in order to make the baking equipment available to deal with most kinds of agriculture products in different conditions.

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