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The Discussion of Influencing Exhausting Water Factors from the Inner Space of Cocoon in Cooking Process

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***Abstract*: -** A simulation of the process of exhausting water from the inner space of cocoon cooked by steaming portion of cocoon cooking machines was performed under laboratory conditions with a thermocouple differential analog input module and a measuring system based on LabVIEW. The temperature of cocoon's inner space and the weight of the cocoon were measured synchronously and continuously. By analyzing the measured results based on the mechanism of exhausting water process, the influencing factors of exhausting water was discussed, which was found that the temperature of cocoon's inner space is the main influencing factor in factory's production, and the main method to control it is adjusting the revolutions of the valve in the cooking machine. （*To whom correspondence should be addressed. Fax: ＋86-512-67503729. Tel: +86-512-67503729, Email: qgchen@suda.edu.cn）

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INTRODUCTION

Cocoon cooking is an important process in silk-reeling project, which influence the quality and the reliability of raw silk. At present, the main method is steam cocoon cooking, the study here is also for it, and it usually includes three processes: permeation, cooking and adjustment. Exhausting water of the cocoon is a visible phenomenon in cooking, whose reverse infiltration action is important to absorb water in cocoon shell of cooking thoroughly the inner shell and protecting the outer shell of cocoon.

However, the main influencing factor of exhausting water process was rarely researched for the reason that the cocoon's inner temperature is difficult to measure. Based on the previous researches carried out by our team (Xu, et al., 2007), in this paper, the explanations about the mechanism of the process of exhausting water from the inner space of cocoon were improved, and the influencing factors were discussed .

MEASURING SYSTEM

To analyze the mechanism and influencing factor of exhausting water process, simultaneous measurements of the weight and inner temperature of cocoons were needed when they were cooked and accordingly a special measuring system was designed. Fig.1 shows the structure of the whole measuring system, it can measure the temperature and weight synchronously and continuously.

The pot with electric cooker was used to heat the cocoons, which simulated steaming portion of cocoon cooking machines. Temperature measuring part consists of K-type thermocouples and NI9211. The hot junction of K-type thermocouple is so small that it can be inserted into cocoon easily to measure temperature, the one more thermocouple can measure the temperature out of its or of a cocoon's different location. Weight measuring part was improved on the basis of former system: the signal of strain gauge was amplified and then was imported into NI9211 directly. Although NI9211 is a thermocouple differential analog input module, it was also an ADC, and it can be used as a high

precision ADC whose ADC resolution is 24 bits. In this purpose, the mode should be chose as ‘constant’ (choosing ‘build in’ means measuring temperature). Compared with the former system, the synchronization of new system was better.

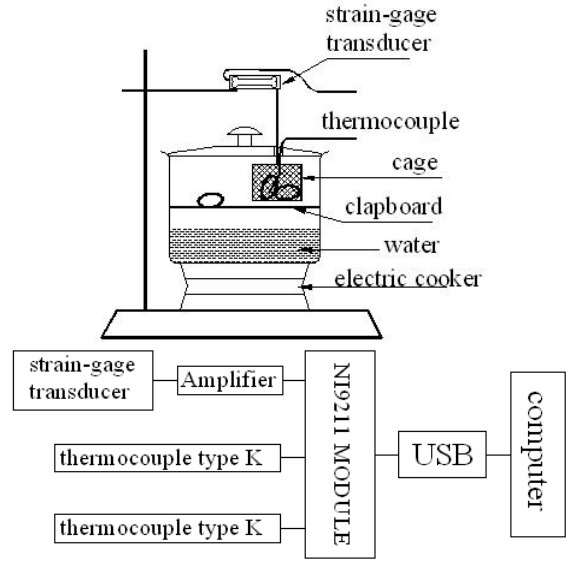

Fig.1. The structure of the whole measuring system

The program of the system was written with LabVIEW, a graphics programming language made by NI Company. The program can make the system measure the temperature and the weight simultaneously and continuously, and it also can save and process the data. The interface of the whole measurement system was showed as Fig. 2.

Fig.2. Program’s interface

METHODS AND EXPERIMENTS

Measuring system

Before measuring weight, the system needed to be calibrated first. Then, like the cocoons entered into steaming room in the cooking machine, after water boiled, put some cocoons into the cage to measure weight and insert the hot junction of K-type thermocouple into one of them to measure temperature.

Experiments about the condition of exhausting and how cocoon pressed recovered

Except for simultaneous measurements, some additive experiments were done for the study. They mainly are exciding cocoon that had absorbed water to let the water flow out and steaming cocoons that had been pressed beforehand to make them recover [2]. The conclusions of them are: the condition of exhausting water is that the cocoon’s inner pressure maintained equal to the outer pressure; after water exhausted the main gas in cocoon’s inner space is vapor.

RESULTS

Temperature of Different Locations of Single Cocoon

To get more exact and credible data, the temperatures of different locations in single cocoon were measured. The method is to insert two thermocouples into a cocoon and make sure the hot junctions were in different locations, which will give out more credible data than measuring different location’s temperature respectively in two cocoons. In this experiment, the main measuring locations were on the top and bottom of a cocoon. Fig. 3 shows the differences between the top temperature and bottom temperature in a cocoon. The result indicates that the difference between the top and bottom was as many as 10℃. The reason of it was: as the exhausting water process went on, the top part became hollow, and temperature went up quickly, while the bottom part still had water, so temperature went up slowly. Therefore the hot junction should always be on the bottom when measuring.

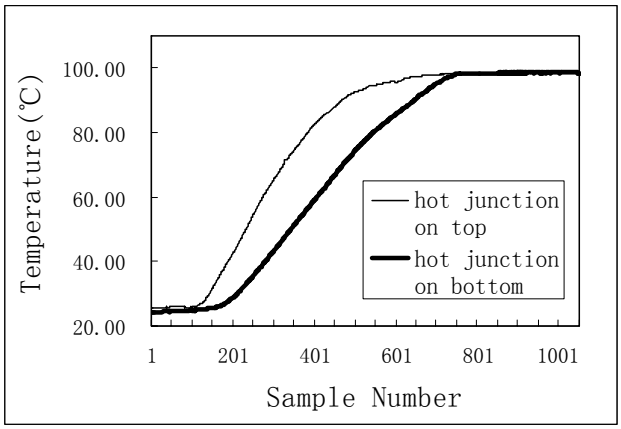

Fig.3. Temperature curves of different locations

Weight and temperature of single cocoon

For the reason of strain-gauge transducer’s precision, many more cocoons should be measured together so that it can get better precision. In this

case, temperature measuring was for single cocoon and weight measuring was for many cocoons, so it is necessary to measure both of them for single cocoon. Using the lever principle can magnify the force, and can measure weight with high precision. Fig.4 shows that the result is consistent to the measurements for more cocoons, so the data from the latter is also credible.

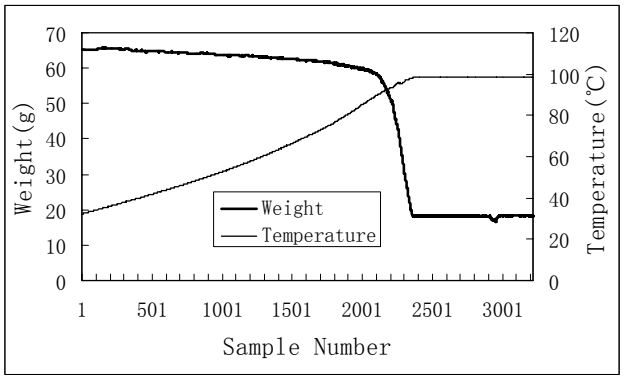

Fig.4. Measurement results for single cocoon

Analysis of Results

By many experiments, it is found that despite the measurement for many cocoons or for one single cocoon, the data is all like what Fig. 4 shows. The conclusions from the figure are: exhausting water process started before the water boiled; exhausting water process became much more quickly when temperature was upon some point; exhausting water process was very slow when the temperature was low. Fig. 5 is a curve whose x-coordinate is temperature and y-coordinate is weight. From Fig. 5, it is seen that rapid declining of weight only happened when the temperature is about 100℃, and the time is very short.

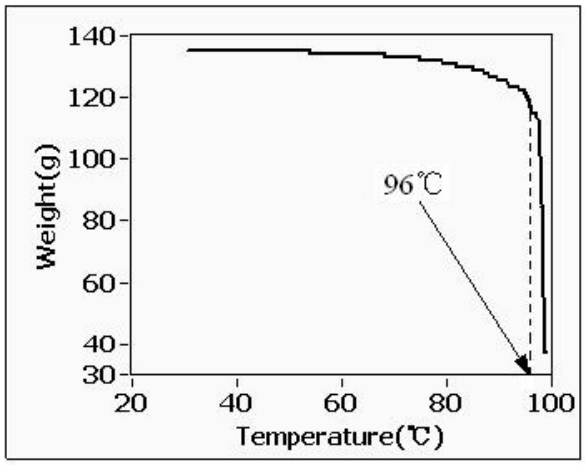

Fig.5. Temperature-weight curve

DISCUSSIONS

Mechanism of Exhausting Water Process

To analyze the mechanism of exhausting water process more scientifically, it is necessary to introduce the concept of Saturated Vapor Pressure. In airtight containers, and at some temperature, liquid's evaporation and liquefaction will be at the same rate finally, and the pressure of the vapor will be invariable, which is called Saturated Vapor Pressure. The Saturated Vapor Pressure indicates the trend that the liquid molecule escaped from liquid, it always increase as the increase of temperature, the slope of it is also increase as the temperature [3]. At some temperature, the Saturated Vapor Pressure minus the current vapor pressure of liquid is called Saturation Lack, which is denoted 'd' here, and it indicate the difference betweens them. The lager d is, the easer the vaporizing is, and vice versa.

According to the concept of Saturation Vapor Pressure, and combining with the three conclusions from 3.3 and two conclusions from 2.3, the mechanism of exhausting water process could be explained as: The cocoon after permeating can be regarded as an airtight container that the gas can't pass but water can, and the condition that the water can flow out continuously is the cocoon's inner pressure equal the outer pressure all the time. In steaming, heat source (hot vapor) heats cocoons continuously, it makes the cocoon's inner temperature rise, the Saturation Vapor Pressure and Saturation Lack increase, thereby, on one side, the speed of water's evaporation increases, on the other side, the volume of it becomes more. So when the inner pressure decline for the reason that inner space of cocoon is larger caused by water flowing out, it make the pressure recruit. And in this case, the cocoon's inner and outer pressure will maintain dynamic balance, so the water can flew out continuously for weight reason.

In conclusion, water-exhausting process is the result of three causes totally: evaporation of water added with pressure when water was boiling and volume expansion of the remaining air. After exhausting water process, the pressure when water was boiling makes the cocoons that have been pressed beforehand recover.

Factor of exhausting water process

From analysis above, Fig.4 and Fig.5, it can be seen that the main influencing factor of exhausting water process is the cocoons' inner temperature. It can be said that the speed and the volume of the water exhausted directly depend on the cocoon's inner temperature. The cocoon's inner temperature

didn’t only depend on the environment temperature. The reason is that temperature rising and evaporation of water need energy, if the environment temperature is high but can not provide more energy, the inner temperature can not rise. This is of great significance to the factory production. In factory’s production, it is important to control the cooking rooms’ temperature, while more attention should be paid to that how much energy the heat source provides. The rapid progress of exhausting water process is only in a short time when the temperature is very high (in Fig. 5, it is from 96℃ to 99℃). For the reason that the time is short, more attention should be paid to controlling the temperature in factory production. According to measurements, the volume of the water a cocoon absorbed is 5-6ml, but according to production experience the most proper volume of the water exhausted is 2.7-3.2ml. And to get proper volume, the cocoons’ inner temperature must be control strictly. In factory’s production, the controlling method is controlling the volume of the vapor that enters the cooking portion of the machine by adjusting the revolutions of the valve of the pipe with holes and blind pipe.

Comparative measurements in factory indicate: When the revolutions of the valve are different, so are the inner temperature and the volume of water exhausted. And this confirmed the analysis above about the mechanism and factor of exhausting water process (Xu, et al., 2008).

CONCLUSIONS

In this study, firstly, by improving special measuring system, the temperature of one single cocoon’s inner space and the weight of it were measured synchronously and continuously. Secondly, by analyzing the measured results based on the mechanism of exhausting water and the influencing factors was discussed; it was found the temperature of cocoon’s inner space is the main influencing factor in factory’s production, and the main method to control it is adjusting the revolutions of the valve in the cooking machine. Finally, the results were confirmed by the measurements of the volume water exhausted and temperature of cocoons’ inner space carried out in factory, which is significant to the factory’s production.

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