The Study About The Sign Characteristics of Fire For Sensing System To Predict Fire

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Abstract— There is a high possibility of fire during cooking when people look away for even a second. Many examples have shown that fire during cooking could lead to a disaster. This study measured the change of surrounding temperature and humidity and the change of food and container temperature during cooking to develop a detector to sense cooking fire and take further action. The result was that the food and container temperature change has a specific form.

Keywords— Fire detector sensor, Surrounding temperature, Surrounding humidity, Food temperature, Container temperature

I. INTRODUCTION

Generally there is a high possibility of fire during cooking. Often a huge fire disaster occurs because people sometimes forget to turn the stove off leaving home. To reduce the damage of property and human lives, we need to find the symptoms of fire in the early stage of fire to prevent it and we need more accurate sensing technology to detect and predict the fire. There are lead dissolution methods and fixed temperature methods using bimetal in the current fire detecting technologies. However they have the disadvantage of ‘slow’ sensing fire. [1] To improve this problem, the differential heat sensor detecting the rate of rise of heat was developed. But its performance fell according to the surrounding environment. Since the advance of the sensor and electronic technology, the technology to measure all kind of gases was made. [2] However it is too expensive to be made as household product. Recently a carbon monoxide fire detector, video smoke detector, and multi sensor detector was developed, but they have not yet been widely used. [3],[4] The most used fire detector is the combined method with photoelectric detector, carbon dioxide detector, and carbon monoxide fire detector currently. However it is still difficult to detect before the start of the fire. [5] The point is that it is hard to make a detector that predicts fire in all kind of situations. The objective of our study is focused to predict the household fire during cooking. To develop a detecting system, we measured the change of surrounding temperature and humidity and the change of food and container temperature and we have found that the food and container temperature change has a specific form.

This fact will contribute greatly to develop a detecting system of household fire.

II. EXPERIMENT EQUIPMENT COMPOSITION

The experimental equipment(Figure1) was created to monitor the whole stage of heating to overcooking of food. This equipment is composed of heating system, food container, ventilator, and measuring device. For the cooking, a normal saucepan as the container and butane gas fuel was used, and ventilating system was installed to ventilate heat and odor of food. A non-contact infrared(IR) temperature sensor, temperature and humidity sensor, and CO₂ sensor was installed to the measuring device.

Figure2 is the measuring device to search for the signs of fire during cooking. The device was installed with non-contact IR temperature sensor, temperature and humidity sensor, and CO₂ sensor. Also UART communication module was attached to send data to computer. Here, non-contact IR temperature sensor directly measures the food and lid of the saucepan temperature while heating.
The temperature and humidity sensor measures the surrounding temperature change, while CO2 sensor measures the change of the surrounding CO2.

Figure 2 shows the change of the food temperature and the surrounding temperature during cooking in the experiment A. Table1. Here, the red line indicates the temperature of the food and the black line indicates the temperature of the surroundings. In the red line, section ①, ②, ③ each shows a timeline. Section ① shows the start of heating the water till the point of boiling. Section ② indicates the boiling of food to right before it burns. Section ③ shows the continuous burning of food. Here the V-shape is suspected to be an interference of steam to IR sensor when the food was boiling. The surrounding temperature starts to rise when the stove turns on. The temperature rises until the food starts to boil, and it maintains its temperature after that. The small fluctuation of temperature is suspected to be happening due to absorbing the air of the pan.

Figure 4 shows the change rate of the surrounding humidity during cooking. The humidity drops until boiling point and it goes up. It shows the heat causes the humidity to drop in the early stage before boiling, but the humidity goes up again being supplied the water vapor after the water starts to boil.

Figure 5 shows the change of the food temperature while cooking under the experiment B condition, Table1. Here, the red line indicates the temperature of the food and the black line indicates the temperature of the surroundings. In the red line, section ① shows the start of heating till the point of boiling, section ② indicates the boiling of food to burning, and section ③ shows overcooking. The temperature in section ① steeply rises then shows little change between section ② and section ③, and the temperature continuously gently rises after section ③. After boiling point, there was a steep drop of temperature momentarily. This is because the vapor is sucked into the ventilator.
Figure 5 shows the change rate of the surrounding humidity change during cooking. It shows that humidity falls after the start of cooking but goes up after boiling point. The humidity goes down due to heat, but the vapor causes the humidity to rise.

Figure 6 shows the change rate of the surrounding humidity during cooking. It shows that humidity falls after the start of cooking but goes up after boiling point. The humidity goes down due to heat, but the vapor causes the humidity to rise.

Figure 7 shows the change of the food temperature while cooking under the experiment condition Ⓒ condition, Table 1. The red line indicates the temperature of the food. Section ①, ②, ③ in this graph shows the start of heating to boiling point, from boiling point to right before burning, and after overcooking. The temperature steeply rises in section ①, and then shows little change between section ② and section ③. However the temperature rises after passing section ③. The black line is the measurement of the temperature around the ventilator. First, the temperature rises gradually then makes an abrupt change after boiling. The vapor absorbed into the ventilator affects the change of the temperature.

After boiling point, there was a steep drop of temperature momentarily. This is because the vapor is sucked into the ventilator.

Figure 8 shows the change rate of the surrounding humidity. The humidity drops then rises again after boiling point. At first, the heat causes the humidity to fall, and the vapor from boiling causes the humidity to rise again. In section ③, because all the moisture is vaporized, humidity drops again.

Figure 9 shows the change of the food temperature while cooking under the experiment Ⓓ condition, Table 1. The red line indicates the temperature of the food and the black line indicates the temperature of the surroundings. In the red line, section ① shows the start of heating till the point of boiling, section ② indicates the boiling of food to burning, and section ③ shows overcooking. The temperature in section ① steeply rises then shows little change between section ② and section ③, and the temperature continuously gently rises after section ③. After boiling point, there was a steep drop of temperature momentarily. This is because the vapor is sucked into the ventilator.
Figure 9 shows the change rate of the surrounding humidity during cooking. The humidity drops until boiling point and it goes up. It shows the heat causes the humidity to drop in the early stage before boiling, but the humidity goes up again being supplied the water vapor after the water starts to boil. In section ③, the burning period, because all the moisture is vaporized and no more water vapor is supplied, the humidity drops again while heated.

Figure 10 shows the change of the food temperature while cooking under the experiment ④ condition, Table 1. Here, the red line indicates the temperature of the food and the black line indicates the temperature of the surroundings. In the red line, section ① shows the start of heating till the point of boiling, section ② indicates the boiling of food to burning, and section ③ shows overcooking. The temperature in section ① steeply rises then shows little change between section ② and section ③, and the temperature continuously gently rises after section ③. After boiling point, there was a steep drop of temperature momentarily. This is because the vapor is sucked into the ventilator.

Figure 11 shows the change of the food temperature while cooking under the experiment ⑤ condition. The humidity drops until boiling point and it goes up. It shows the heat causes the humidity to drop in the early stage before boiling, but the humidity goes up again being supplied the water vapor after the water starts to boil. In section ③, the burning period, because all the moisture is vaporized and no more water vapor is supplied, the humidity drops again while heated.

Figure 12 shows the change of the food temperature while cooking under the experiment ⑥ condition, Table 1. Here, the red line indicates the temperature of the food and the black line indicates the temperature of the surroundings. In the red line, section ① shows the start of heating till the point of boiling, section ② indicates the boiling of food to burning, and section ③ shows overcooking. The temperature in section ① steeply rises then shows little change between section ② and section ③, and the temperature continuously gently rises after section ③. After boiling point, there was a steep drop of temperature momentarily. This is because the vapor is sucked into the ventilator.
Figure 13 shows the temperature of food and surrounding in heating process (experiment condition Ⓜ). The temperature of food goes up in the early stage and maintains constantly when the food is boiling, but it rises distinctly again from the boiling point while heating the food.

Figure 14 shows the change rate of the surrounding humidity during cooking under the experiment Ⓜ condition. The humidity drops until boiling point and it goes up. It shows the heat causes the humidity to drop in the early stage before boiling, but the humidity goes up again being supplied the water vapor after the water starts to boil. In section ③, the burning period, because all the moisture is vaporized and no more water vapor is supplied, the humidity drops again while heated.

Figure 15 shows the measured amount of CO₂ generated while heating food with butane fuel. It shows the measured amount is each different by the intensity of the flame but the amount is constant regardless of the time when the flame is fixed.

IV. CONCLUSION

Fundamental experiments have been conducted to develop the fire sign detecting sensor that predicts fire during cooking. We could obtain the following results by measuring food temperature, surrounding temperature and humidity, and the amount change of CO₂ by the heat generated when the food in various containers is heated.

1) It is difficult to predict the burning point as the fire sign by measuring the change of the surrounding temperature because it is affected by surrounding environment even though the temperature change is happening during cooking.

2) The surrounding humidity is dropped to start heating until the food is boiled and it goes up from the boiling point. But it is difficult to predict the burning point by measuring the humidity transition.

3) The CO₂ amount of the surrounding only depends on the intensity of the flame during cooking and it is not relevant with the temperature of the food heated.

4) The temperature of the food and container goes up in the early stage and maintains constantly when the food is boiling and it rises distinctly again from the burning point while heating the food.

By conducting the experiment, monitoring the temperature of the food or container is much better than others in order to predict the sign of the fire during cooking.
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