Use Air Circulation Fan to Reduce Temperature Distribution in Electric Smokers

Part 2: Study the Effect of Fan Speed on the Temperature Distribution in an Electric Smoker

Ver 1.0 (August, 2019)

Introduction

This is the Part 2 of a series temperature profile studies that we have performed in a Bradley electric smoker. The purpose of these studies is to find out the effectiveness of Auber's Air Circulation Fan kit in reducing the temperature distribution in electric smokers. In Part 1, we have demonstrated that there is a significant reduction on the temperature variation in a smoker when our circulation fan is running, either in an empty smoker or a smoker loaded with cardboard sheets or boxes. In this part, we examined the effect of fan (motor) speed on the temperature distribution in an electric smoker.

In Auber's Air Circulation Fan kit (part number: CIRFAN), 12 VDC is used to drive a small DC motor to power the fan. However, this motor can accept any DC voltage up to 24 V. The rotation speed (RPM) of the motor has a linear relationship with the voltage as shown in Figure 1. Higher the voltage, higher the rotation speed, and higher the amount of air can be moved by the fan. We have found that, in general, higher fan speed can reduce the cooking time and reduce the temperature distribution in a smoker, but it is also likely to increase the vibration noise from the fan.

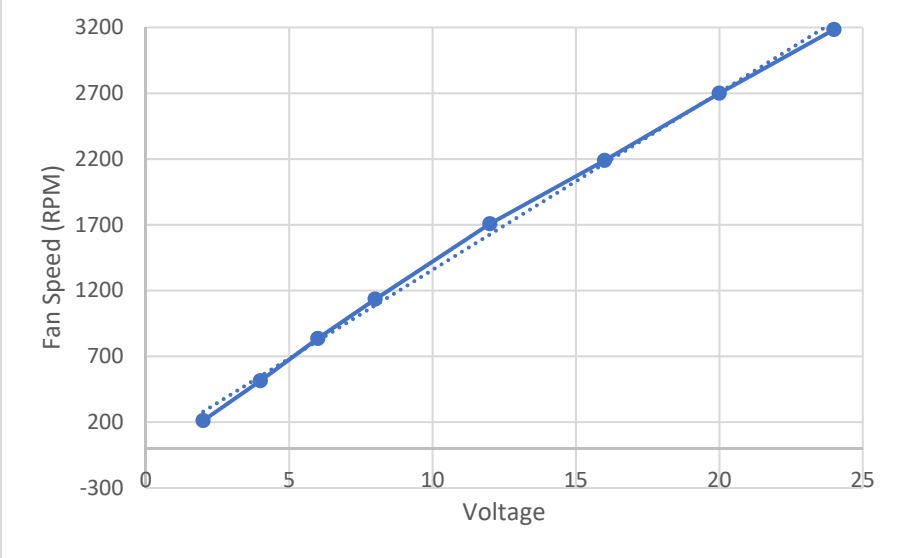

Figure 1. The measured motor rotation speed in CIRFAN kit increases linearly with its driving voltage in the range between 2 V to 24 V.

As some customers expressed their interests in adjusting the fan speed, we will show some results from our previous tests to help these customers get started with their exploration. In this report, we will show testing results on how the cooking time changes with the voltage supplied to the motor. We will also show testing results on how the temperature profile will change with the voltage.

Equipment and Method

The details of the equipment and the method we used have been described in the Part 1 of our report. Only the differences in the equipment and method in Part 2 of the study is described here.

Equipment

An Auber's CIRFAN kit has been previously installed to the left corner of a 4-racks Bradley Original Smoker, just below the rack #1 (numbered from the bottom). The power to the motor in the CIRFAN kit was supplied by an adjustable 3 V ~ 24 V DC adapter. (Please see the Appendix for the actual power adapter that was used in this study.)

Totally 18 probes were used in this study. The lay out of the probes is identical to what we have used in Part 1 of this study "Use Air Circulation Fan to Reduce Temperature Distribution in Electric Smokers". The picture in Figure 1(a) showed how these probes are mounted. Cardboard boxes of different size were arranged in the smoker as shown in Figure 1(b) to simulate the obstruction effect on the air flow from food placed in a smoker.

(a) (b)

Figure 2. (a) Totally 18 temperature probes were installed on a 4-rack Bradley Original Smoker. (b) Different sized cardboard boxes were randomly arranged in the smoker to simulate the obstruction on the air flow by food placed in a smoker.

Method

The temperature profiles in a smoker oven with the circulation fan powered at different voltages were recorded under different conditions:

1) The smoker was either empty or loaded with cardboard boxes. The set temperature was 225°F. The smoke generator was turned on.

2) The smoker was loaded with cardboard boxes. The set temperature was of 150°F. Smoke generator was turned off or turned on.

In each test, the readings from all 18 probes were recorded. The standard deviation (SD) and the range of the data (i.e., the difference between the highest temperature and the lowest temperature) from all 18 probes were calculated to describe the temperature distribution in the smoker.

The cooking time needed for smoking salmon at different fan speed (by varying the voltage) were also recorded. In each test, salmon meat was cut into 1 ¼" wide strips. The original weight of each piece of salmon strips was recorded, and they were all between 220 grams to 280 grams range. Salmon strips were cured with dry brine overnight. Before smoking, they were dried in air with a fan for 2 hours. The temperature in the smoker was maintained at 150°F by an Auber's PID controller. The food temperature was monitored by inserting an Auber's mini probe (part number: WS-SENSOR22). The cooking time was counted as from the recorded when the internal temperature reached 125°F.

Results and Discussions

1) At set temperature of 225°F.

Two tests were performed in this section at the set temperature of 225°F. One test was done in an empty smoker, the second test was done in the smoker loaded with cardboard boxes. The smoke generator was turned on. The ambient temperature was in 80°F ~ 90°F range. The voltage supplied to the motor was varied from 0 V to 24 V.

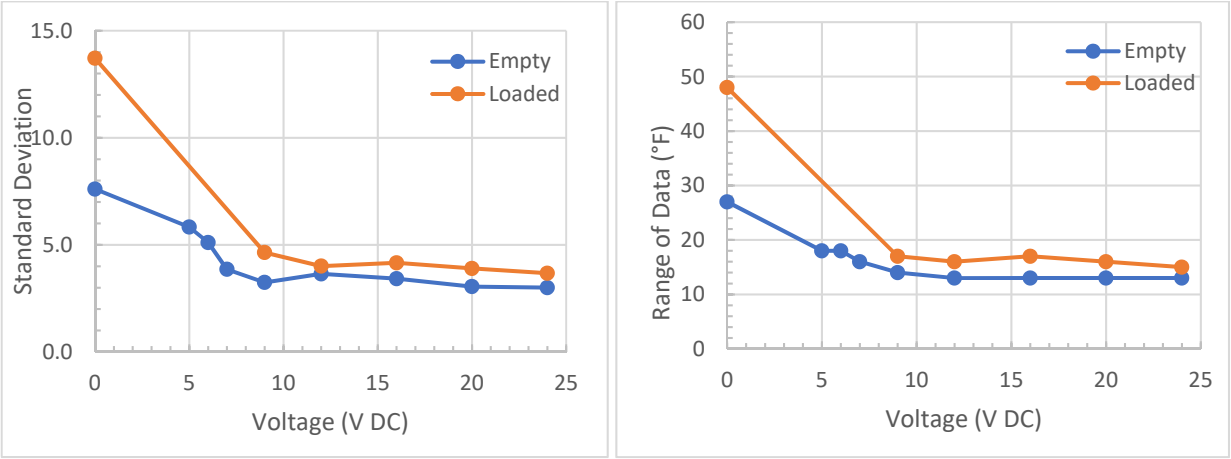

Figure 3. At 225°F, either in an empty smoker or in a loaded smoker, as the voltage to the motor increased, fan speed increased, the standard deviation (left) and the range of the data (right) decreased and gradually converged.

As shown in Figures 3, both the standard deviation and the range of data (i.e., temperature) decreased significantly when the voltage of the motor was increased from 0 V (i.e., circulation fan was turned off) to 9 V. As the voltage was increase from 9 V to 12 V or higher, there is no significant change in the standard deviation or the range of the data.

2) At set temperature of 150°F.

This group of tests were performed at the set temperature of 150°F. The smoker loaded with randomly arrange cardboard boxes. The smoke generator was either turned off or turned on. The ambient temperature was in 80°F ~ 90°F range. The voltage supplied to the motor was varied from 0 V to 24 V.

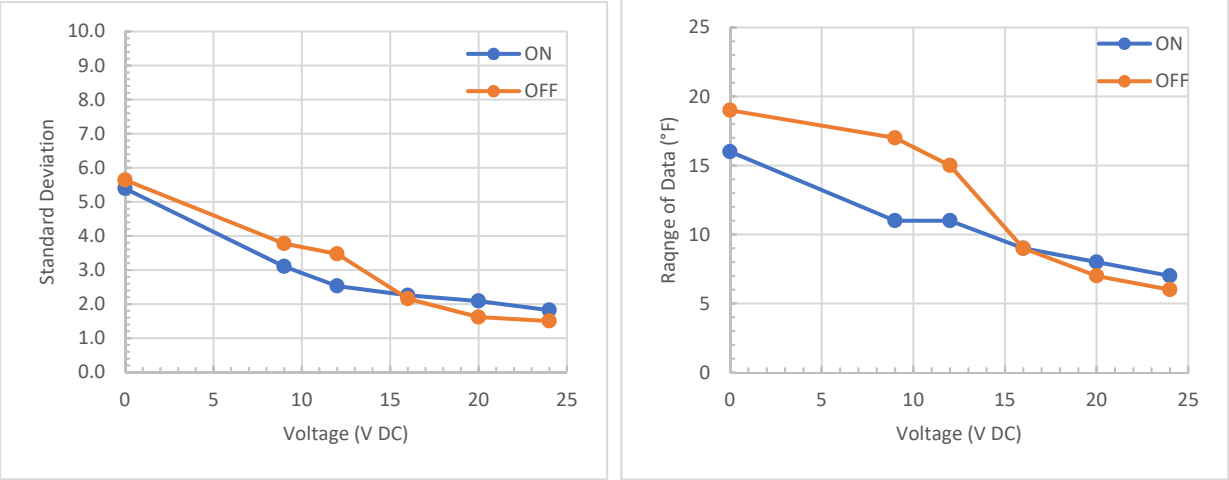

Figure 4. At 150°F, in both situations where the smoke generator was turn on (blue markers) or the smoke generator was turned off (orange markers), as the voltage to the motor increased, fan speed increased, the standard deviation (left) and the range of the data (right) decreased.

The data in Figure 4 shows that the results from smoking at 150°F are slightly different than the results from smoking at 225°F. Both the standard deviation and the range of temperature variation dropped when the voltage of the motor was increased from 0 V, i.e., the circulation fan was turned off. However, the lines of the standard deviation and range of data doesn't show a trend of converging, as we have seen in Figure 3. The reason for this difference is not clear.

3) Reduction on cooking time.

In this group of tests, real smoking was performed. The cooking time need for smoking salmon at different motor voltage was recorded. The cooking time needed under no circulation fan (i.e., when motor voltage is 0 V) was considered as the "reference time". Cooking time recorded at 12 V, 16 V, and 20 V are compared to the "reference time" and are converted to percentage values.

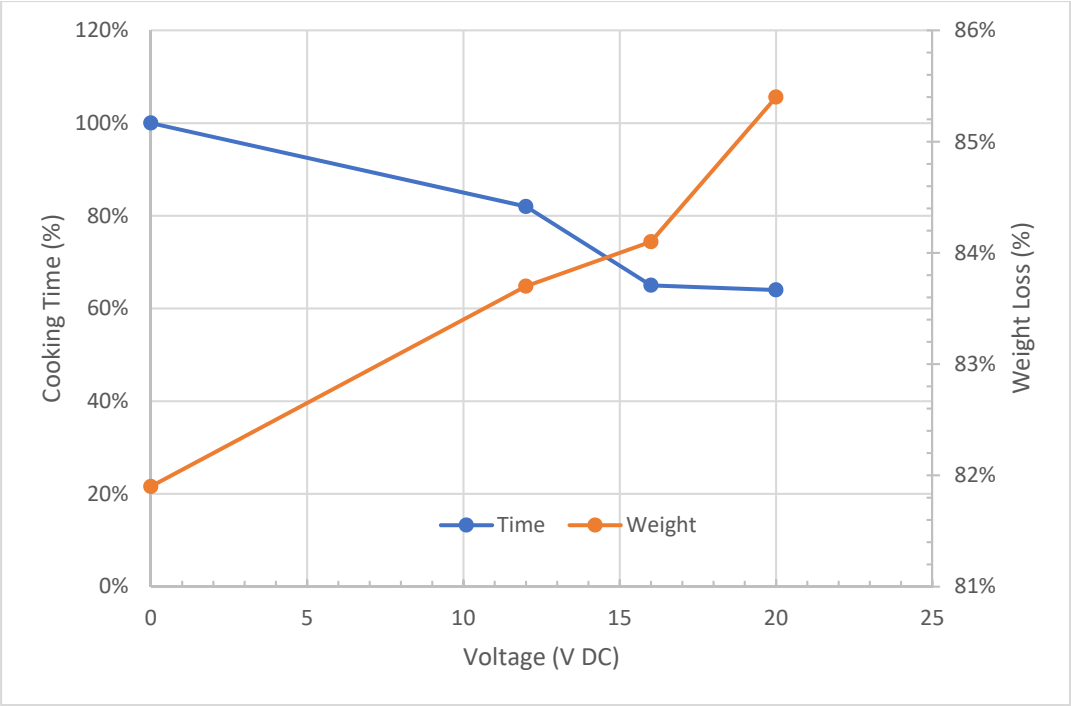

Figure 5. Cooking time was reduced as the voltage supplied to the motor was increased to 12 V, 16 V, and 20 V. In the same time, the weight of smoked salmon increased slightly with the increased voltage.

When Auber's CIRFAN was running at 12 V, the cooking time was reduced to 82%; when the voltage was increased to 16 V, the cooking time was reduced to 65%; and when the voltage was increased to 20 V, the cooking time was reduced to 64%. In our tests, the salmon meat cooked with circulation fan turned on was more tender and juicier than the salmon meat cooked without circulation fan. The average final weight of salmon strips cooked without circulation fan was 81.9% of the original weight. In contrast, the average weight of salmon strips cooked with the circulation fan powered at 12 V, 16 V, and 20 V were 83.7%, 84.1%, and 85.4% of the original weight.

In all of these tests, the temperature was maintained at 150°F. Then why the salmon was cooked faster with higher voltage (i.e., higher fan speed)? We speculate that there are two reasons behind this: 1) Faster fan speed helps to circulate more hot air around the food. As a higher volume of hot air come in contact with the food, essentially more heat exchange happens between the hot air and the surface of the food. 2) Faster air circulation helps to reduce water evaporation and reduce the time needed to bring up the internal food temperature. With faster air circulation, the surface layer of brined salmon strips was dried faster, which actually helps to seal more juice in the meat. This means less water evaporation could happen during the cooking process. Evaporation absorbs heat and slows down the temperature rising.

Conclusions

By varying the voltage supplied to the motor in CIRFAN kit, different fan speed can be achieved. A higher voltage produces a higher fan speed, and can result in a more uniform temperature profile in a smoker. The cooking time can also be reduced when the circulation fan spins at higher speed. However, higher speed is usually associated with higher noise from the vibration and reduce the life of the motor due to higher heat is generated.

When cooking at 225°F, supplying 9 V or 12 V power to the motor is recommended. It achieves a good balance between the maximizing the improvement on temperature uniformity in a smoker and minimizing the vibration noise from the fan.

Appendix

A. Adjustable power adapter

Here is the link and the image of the adjustable power adapter used in this study. You can use similar adapter to supply the power.

HGJI 60W Adjustable AC/DC Adapter Switching Power Supply 100-240V to 3.3-24.7V 2.5A 50-60hz with LED Voltage Display US Plug (link: https://amzn.to/2JLUYnJ).

(END)

Auber Instruments
5755 North Point Parkway, Suite 99
Alpharetta, GA 30022, USA
www.auberins.com
E-mail: info@auberins.com Tel: 770-569-8420