Installation Evaluation for Air Circulation Fan Kit, for Smokin-it #2 Smoker (Sept, 2019)

Introduction

The purpose of this study is to determine the optimal location for installing Auber's Air Circulation Fan kit in Smokin-it brand smoker.

This study was based on a similar set up and method used for Bradley Smoker. For more details of the setup and performance analysis, please refer to the following link.

https://www.auberins.com/images/Manual/CIRFAN%20Temperature%20Study_Part1_profile_v1.0.pdf

Equipment and Method

Equipment

A #2 Smokin-it Smoker was used in this study. As the smoker had been used before, all walls inside were in dark brown, which represented the typical heat reflection condition in home smokers.

All probes used in this study had Platinum (PT1000 RTD, Class A) sensing elements. Probes were calibrated with the controller/thermometers together on a Fluke 9100 dry-well calibrator. The reading accuracy was within +/-1°F in the testing temperature range.

Totally 17 probes were used in this study. On the third rack (rack #3) from the bottom, a free-hanging probe (part number: WS-SENSOR17) was clipped to the center by a probe-clip (part number: Pclip). It was used for controlling the temperature of the smoker cabin.

On rack #1, #3, and #5, five probes were mounted on each rack: one probe was clipped at the center and four probes at corners. The probes mounted at corners were Auber's miniature probes (part number: WS-SENSOR22), which were 2 mm in diameter with 20 mm long. They were mounted vertically at the intersection of the second wires from their nearest two sides, i.e., they were 2" (50 mm) from the side wall and 2" (50 mm) from the front wall or the back wall. This is to ensure that probes installed at the corners were vertically aligned. At the center of each rack, Auber's free-hanging probe (part number: WS-SENSOR17) were mounted horizontally by a probe-clip (part number: Pclip).

On rack #2 and #4, only a free-hanging probe (part number: WS-SENSOR17) were clipped at its center by a probe-clip. No probes were mounted at the corners.

Each probe is named by its rack number and its relative location in the smoker. For example, "1_Center" is the probe on the center of the #1 rack, and "2_Back_Left" is the probe at the back-left corner of the #2 rack. The left side or the right side of the smoker is defined as the same way we are facing the smoker and looking into it.

Figure 1. total 17 temperature probes were installed on this testing smoker.

An Auber WSD-1500H controller was used with the center probe on the second rack (i.e., probe 2_Center) to control the smoker cabin temperature. The rest of the probes were read either by Auber's WSD-1500H or by SYL-2615, both of which were PID controllers with Wi-Fi capability. These controllers were used as thermometers to recorded temperature readings from these probes. All temperature readings were taken at least 30 minutes after both the reading of the control probe and the power output of the controller were stabilized at the set point.

Method

The temperature profile in a smoker oven with or without the circulation fan was tested at setpoint of 170°F in an empty smoker or in a smoker with blocks of cardboard sheets or cardboard boxes to block the airflow.

The temperature profile in an empty smoker can give us a general idea of the whether a circulation fan would help reduce the temperature variance in a smoker, but it does not necessarily represent the situation under a real cooking process. The cardboard sheets and cardboard boxes were randomly selected and arranged on each shelf to simulate food chucks of different size.

Figure 2. Cardboard boxes and cardboard sheet of different size that were selected and randomly placed in the smoker to simulate different food chunks.

Temperature profile of smoker with circulation fan in three different locations were tested.

Configuration 1: Fan was installed on the bottom right back corner. The motor was on the outside of the backwall. The direction of air movement was from bottom to the top.

Configuration 2: The fan was installed on the top right back corner. The motor was on the outside of the right-wall. The direction of air movement was from top to the bottom.

Configuration 3: The fan was installed on the top left back corner. The motor was on the outside of the left-wall. The direction of the air movement was from back to the front.

Results

Data are summarized in the table. The testing conditions are given in the first a few rows, temperature readings are listed in the middle, and the statistics of the data are given in the bottom rows. The probe "3_Center" is denoted by an asterisk sign, indicating it is the temperature control probe.

Under each testing condition, we did one test with the circulation fan turned off and one test with the circulation fan turned on. Data from these two tests are listed side-by-side in for easier comparison.

The data from each test is listed in a column. In each column, the highest reading is marked in red color, and the lowest reading is mark in blue color. The data average, standard deviation, and the range of the data (i.e., the span between the minimum reading and the maximum reading) are calculated and listed at the bottom of the table.

	Set Temp.	170									
	Blow direction	bottom right corner up					top back down			top back forward	
	Fan voltage	0	12	0	12	24	0	12	24	12	24
Condition	Load	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	1_Back -Right	166	171	167	176	170	167	164	165	162	169
	1_Front-Right	167	166	168	168	168	166	174	172	164	177
	1_Back-Left	182	174	169	175	170	168	168	167	165	175
	1_Front-Left	169	168	166	168	167	167	166	165	158	163
	1_Center	174	170	190	172	170	188	180	175	179	176
	2_Center	169	169	177	169	169	171	176	170	180	175
	3_Back -Right	171	176	176	179	175	176	172	171	160	168
	3_Front-Right	168	164	166	166	166	166	166	169	160	171
	3_Back-Left	175	172	173	173	171	172	166	166	159	165
	3_Front-Left	176	168	166	167	168	172	167	167	162	163
	*3_Center	170	170	170	170	170	170	170	170	170	170
	4_Center	168	168	173	169	168	169	167	167	170	167
	5_Back -Right	171	173	170	174	171	171	165	170	158	163
	5_Front-Right	170	170	167	168	168	167	164	165	162	168
	5_Back-Left	174	172	170	173	171	171	163	169	158	163
	5_Front-Left	173	171	168	174	172	167	172	173	156	162
Probe Reading	5_Center	170	170	173	172	171	169	166	167	163	164
	Average	171.3	170.1	171.1	171.3	169.7	170.4	168.5	168.7	163.8	168.1
	Standard Deviation	3.97	2.91	5.95	3.60	2.14	5.26	4.73	2.95	7.05	5.11
	Max	182	176	190	179	175	188	180	175	180	177
	Min	166	164	166	166	166	166	163	165	156	162
Statistics	Max-Min	16	12	24	13	9	22	17	10	24	15

Discussions

The quality of temperature uniformity can be evaluated by the statistics of our test result. In particular, the standard deviation and the range of temperature (Max-Min) are the most important parameters. Comparing these different blowing directions, Configuration 1 (blowing from bottom up) gave the best result.

For the empty smoker, the temperature was fairly uniform even without a circulation fan. Turning on the circulation fan can improve the evenness of the temperature distribution slightly.

When the smoker was loaded with simulated food, the effectiveness of the circulation fan became clear. When there was no circulation (fan voltage was set to 0V), the center of the first rack was the hottest (190 and 188F). This was because the center of the first rack was the closest to the heater. The loads on the racks blocked the hot air circulation so that heat was accumulated at this spot. It was 20 degrees higher than the set temperature. Since the ambient temperature was 80F, the center of the first rack was about 22% hotter than the set temperature in terms of percentage of increase (20/(170-80)). It means if the set temperature was at 225F, this spot could be 32F hotter. When the fan was turned on, the temperature of this spot reduced to the 170-172 degree. The hottest spot was shift to a different location and was only 9 degree higher when the voltage of the fan is at 12V, and 5 degree higher when voltage of the fan increased to 24V.

Configuration 2 (blowing from top to the bottom) was less effective when fan voltage was at 12Volt. When the voltage increased to 24V, the result was comparable to the Configuration 1. We think this was because the fan needs more speed to overcome the gravity convection of the hot air. The advantage of this configuration is that installing the fan on top will avoid collecting the dropping grease on the fan blade. However, running the fan at higher voltage increases the noise and vibration of the system. It should be noted that this result can also be applied to model 1, 2 and 3 of the Smokin-it smoker because they have the similar height. More test is needed for model 3.5, model 4, and model 5 of Smokin-it because they are taller. For the same fan voltage, the speed of air at bottom might be lower.

The result of Configuration 3 (blowing from the top of the back wall to the front) was not good. It was even worse than the result without using the circulation fan. Originally, we though this configuration does not have the disadvantages of the other two configurations (collecting grease, and against gravity convection of the hot air). We think the problem was due to that the air input gate is too wide. It can't form a good air circulation

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