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Understanding and maintaining airflow within your smokehouse

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Thermal processing ovens — known as smokehouses, Batch ovens or forced air convection ovens — utilize many of the same variables. Some of the basic design principles will be discussed herein; however, the focus will be on the importance of supply airflow dampers, sometimes referred to as rotating dampers or wigwag dampers, that directly control the oscillating airflow within the oven cabinet and the pathway of the oscillating airflow.

What does a smokehouse really control?

Smokehouses basically control four critical variables: wet-bulb temperature, dry-bulb temperature, cooking time and airflow. Most oven manufacturers use probes to monitor temperatures and microprocessor controls to add and control cooking cycles or recipes. The major difference among batch oven manufacturers is the last variable, airflow.

1. **Wet-bulb temperature:** The main message here is, "Change your socks!" The wet-bulb temperature is the temperature at which moisture is evaporating from products' surface. The wet-bulb socks should be replaced regularly, at a minimum of twice per week, and more often when using longer cook processes that use natural smoke. Wet socks get contaminated by liquid and natural smoke and dry out excessively, not re-absorbing water correctly. Your whole cook process is based on controlling the temperature at which moisture is evaporating from the surface of your product, so keep your socks clean!
2. **Dry-bulb temperature:** The dry-bulb temperature is simply the temperature of the oven. Contaminants, mainly smoke, can build up on the stainless steel probe over time and create a delayed or improper reading, so keep the tip of your probe clean.
3. **Cooking time:** The cooking time in a batch oven process includes a series of steps that creates a cook cycle or recipe. Most new ovens are controlled by microprocessors or industrial computers for repeatability, documentation, networking, maintenance, etc.
4. **Airflow:** The definition of Airflow in a batch oven encompasses a few different important factors:
 - Supply fan(s)/blower: Most manufacturers of large batch ovens

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use a single supply fan/blower based on the gross CFM requirement; however, some foreign manufacturers still use multiple smaller fans for the CFM requirement. Also, most batch ovens utilize a single-speed fan, whereby the supply airflow is fixed at one speed and dampers are used to oscillate the airflow. Variable-speed main fans can be advantageous when various air changes are required for many different products, such as processing beef jerky, hot dogs, or even the fermentation of dry sausages in the same oven.

- Supply damper(s): Supply dampers are designed to oscillate the airflow breakpoint (where the two supply airflows meet) within the oven cabinet with the goal of creating a consistent breakpoint from one side of the oven to the other. Some designs rotate the dampers continuously and some move back and forth, but all supply dampers have the same goal: to create oscillating airflow and a breakpoint by changing the velocities of the airflow coming out of each of the supply ducts.
- Air velocity, volume and the airflow path: Batch ovens are convection ovens that use high-velocity, oscillating airflow to move air turbulently throughout the oven cabinet. It is very important that the material handling rack (truck, cage or tree) be designed in conjunction with the airflow pattern. For example, many processors have used six-wheel trucks (three wheels on each side) due to the ease of rotating and turning. However, the structure that surrounds the wheels of these trucks hinders the airflow pattern, causing an inefficient breakpoint which leads to enhanced processing inconsistencies.

For years oven manufacturers have used oscillating airflow through the use of supply airflow dampers as a means of providing the best possible airflow within the oven cabinet. However, even the best maintained batch ovens still have inconsistencies due to the nature of the technology. These inconsistencies can translate into temperature variations of 2 degrees F to 8 degrees F within the oven cabinet. It is extremely important, therefore, to understand the mechanics of the supply dampers and make sure that they are positioned and working properly to minimize the batch oven inconsistencies.

Many people refer to batch oven inconsistencies as hot spots or cold spots; however, the reality is that there is a certain degree of hot and cold spots in all batch ovens. There are many factors that can contribute to or exaggerate batch oven inconsistencies: rack design, control of the breakpoint, width of the oven, air supply equipment location and path, air velocities, type of products being cooked, recipes, etc. Limiting the inconsistencies in batch ovens is best accomplished through maintaining the positioning of the supply airflow dampers and eliminating any obstructions in the airflow path.

Calculation of airflow (air changes)

Air changes are defined differently among oven manufacturers. This article will address the calculation based on the total cubic feet of an empty oven cabinet without racks, which will tell us how many times the volume of air within the oven cabinet has been replaced per minute, each change being one air change.

- Air change: The total CFM of the re-circulated air volume divided by the inside oven cabinet volume (cu.ft. = length x width x height from the floor

to the bottom of the ductwork)

- To calculate the re-circulated air volume, measure the total area of the supply duct outlet (square feet), which are sometimes referred to as cones or slots in square feet and multiply by the sum of the velocities of the supply airflow in feet-per-minute (fpm) from each supply duct.
- Total area of supply outlet 1.35 square feet x total supply velocity 8000 fpm (6000 fpm + 2400 fpm) = 11,340 cfm

11,340 cfm divided by the oven volume 900 cu.ft. = 12.6 air changes

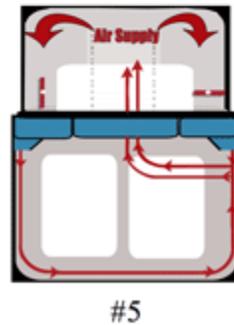
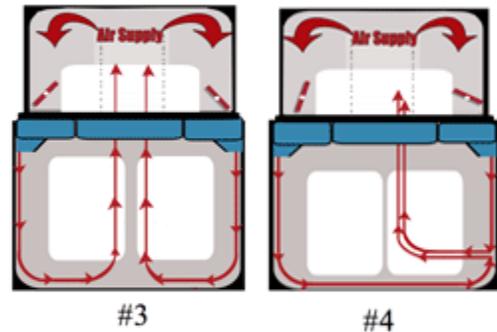
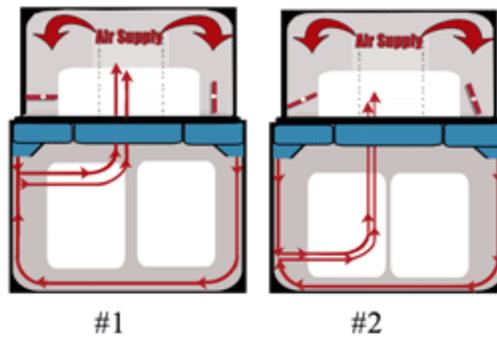
Supply airflow dampers: Controlling the breakpoint

Among the many variables that effect the performance of a batch oven, one of the most important is the airflow supply dampers, often referred to as rotating dampers or a version of wigwag dampers. The rotation and position of these dampers directly affects the oscillating airflow around products within the oven cabinet by varying the velocities of the airflow from one supply duct to the other, creating a breakpoint where the two airflows meet.

Below are end-view sketches of a batch oven for visualizing how the oscillating airflow of the breakpoint moves around the oven cabinet. The dampers are perpendicular to each other, which is extremely important to maintain. A 5-degree difference can greatly effect the location and performance of your breakpoint.

End view of a typical smokehouse

Therefore, the performance and consistency of batch oven oscillating airflow is directly dependent upon the performance of the supply dampers. In the first sketch (right), the breakpoint needs to be positioned at the height of the product, not too high, which bypasses the product envelope, and not too low that it is not directing airflow to the upper corners of the product envelope. The damper blades are usually adjustable to allow adjustment of the blades to close off more of the airflow or to allow more airflow to pass, thereby raising or lowering the maximum breakpoint height.

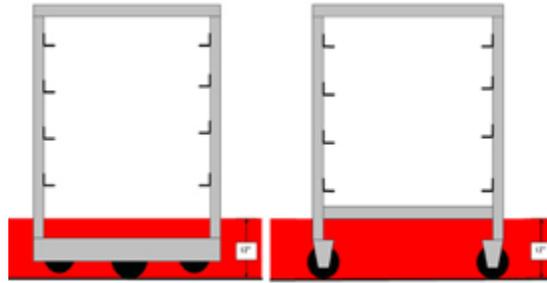


The speed at which the breakpoint moves is dependent upon the damper shaft's revolution per minute. Depending on the oven manufacturer, the damper speed can be as low as 0.5 RPM up to 2 RPM. The oscillating airflow is constantly picking up product surface moisture released from the products' surface. In order to get good heat transfer and enough exposure to the oscillating airflow for even drying of product, the RPM of the supply airflow dampers should run between 0.25 and 0.5 RPM, or its equivalency if the dampers move back and forth from 0 degrees to 90 degrees.

Arrows represent the general movement of the high-velocity airflow based on the position of the supply airflow dampers.

Product loading and material handling

The design of a rolling rack, widely known as a truck, can greatly hinder a batch oven's performance. As referenced above, the airflow is supplied through supply ducts down the oven wall and must travel under the truck(s) in order to create a breakpoint up the opposite side of the oven's wall. Any obstructions in the path of the high-velocity airflow circumvent the airflow to travel elsewhere. There should be at least 12 inches of clearance



On the left is a poorly designed rack that completely impedes the airflow path from the floor up to 12 inches. On the right is a well-designed rack where the airflow path has very little obstruction up to 12 inches from the floor.

between the floor and product to enable the airflow to travel from one side of the oven to the other. When using a rail system versus a rolling truck system, this issue only becomes important if your product is hanging lower than 12 inches from the floor. It is very difficult to achieve a controllable breakpoint if there are obstructions in the pathway of the high-velocity airflow.

Looking from the wall of the oven towards the truck, referencing the sketches of trucks, it is clear to see how large of an impact the design of the truck has on the control of the airflow.

Heat source / heat transfer of the airflow

The heat source is the type of utility that heats the re-circulating airflow within the oven cabinet such as directly burning natural gas or propane, using steam through a coil which the air passes through, electrical elements which the air passes through, an in-direct use of natural gas by burning the gas into a tube which the air passes over, or other heat sources. There are many different advantages and disadvantages of each type of heat source, but all of these heat sources have one common goal: to heat the re-circulating airflow within the oven. Heat sources can influence the performance of an oven when they're not functioning properly or they're not designed properly; however, when designed and working properly, they should not be a significant factor in the performance of the airflow or the cooking process.

SOLUTION:

Total-Flow-Control (T-F-C) takes airflow control of smokehouses to a whole new dimension. With Total-Flow-Control, it is now possible to control the airflow breakpoint in your smokehouse automatically — based on the internal temperature variance of your product — throughout the entire cook process.

T-F-C also allows you to pre-program the breakpoint by having complete control over your supply dampers, eliminating the temperature variances found in smokehouses.

Learn more about Total-Flow-Control
