Global Cooling

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Part 5 in a Series of Informative Articles about Forced-Air Precooling

We are pleased to present an article by Jim Thompson, who has been an adviser to our company for a number of years, and a great help to us. *(To contact Jim, eMail to jamfthompson@gmail.com, or see UC Davis page here.*

Measuring Product Temperature in Forced-air Cooling

by Jim Thompson

Effective use of a forced-air cooler requires that a person be assigned the responsibility of checking product temperature and removing product from the cooler as soon as it reaches desired temperature. Removing product from the cooler too quickly results in it being too warm. Cooling too long will cause unnecessary moisture loss from the product and might, in some cases, cause low temperature damage. It also results in less overall cooling capacity during the day and excess electricity use.

The first step in managing product temperature in a precooler is to calibrate the thermometer used for measuring product temperature. Many items are cooled to near freezing so calibration with an ice bath is a very effective option. Fill a glass with crushed ice and then add clean water. Use the temperature probe to stir the mixture for several minutes, until it reaches a minimum temperature. If the thermometer is accurate it will read 32.0°F (0.0°C). Some units can be adjusted to read correctly. If the unit cannot be adjusted, put a small sticker on it indicating how many degrees must be added or subtracted from the reading to obtain an accurate reading. Mark the calibration date on the unit. Units should be calibrated on a regular schedule, such as quarterly.

The goal in produce temperature measurement is to determine the actual product temperature, sometimes called pulp temperature. The traditional approach is to pierce the product with a thin probe and measure the temperature near its center. Make sure the probe is sanitized before use or throw away product that has been probed. Ideally, we would prefer a device that nondestructively measures internal product temperature, but equipment like this is not yet available.

I have seen the use of infrared thermometers that do not use a probe. But they measure the temperature of the surface they are exposed to, not a true pulp temperature. If placed above a fruit they measure the surface temperature of the fruit. If the product is in a package they will measure the surface temperature of the package. Also remember they measure the average temperature in a circular area in front of the sensor. The area gets larger as the unit is held farther from the surface and it is easy to average in the temperature of the surrounding packaging. Infrared thermometers also can be adjusted for “emissivity” *(consult your owner's manual.)*

In forced-air coolers there is always a difference in temperature between product in different locations. The cooler should be managed on the basis of the warmest product. As a general rule, the warmest product is in the boxes located where the cooling air leaves the pallet and in a pallet farthest from the cooling fan. In a tarped cooler, the warmest product usually is next to the air return channel, under the tarp, and in the pallet farthest from the fan. When this product reaches the desired temperature, the fan can be stopped and the product removed from the cooler. If the product is left in position and covered by the tarp, the best way to maintain proper temperature without over-cooling is to use a controller that automatically shifts the pressure fans into a lower-RPM “holding mode”, and sends a signal that the load or batch is done. In this scheme, the last load of the day can be left overnight, personnel can be sent home early and overtime expense slashed, and the product can be removed the next morning, when oftentimes there is little else to be done. Alternatively, you can keep staff on site, and when the produce reaches proper temperature, at the very least remove the tarp and separate the pallets front to back, so that the cooler air can reach them and prevent respiration from re-warming.

Record product and lot information, initial and final product temperatures, cooling time and room air temperature. This information allows the operator to verify that each lot was properly cooled and helps in monitoring performance of the forced-air cooler.

The rate of heat loss from a product in a forced-air cooler depends directly upon the temperature difference between the product and the cold air. (*temperature differential, or “TD”.)* This means product temperature drops quickly at first, when that difference is the greatest. Later in the cooling cycle - as the product temperature decreases, and so does the Delta-T - the rate of product temperature reduction decreases. This causes the typical temperature pattern illustrated in the figure below. In this example, the product starts at 68°*F* (20°*C*) and cooling air is set to 32°*F* (0°*C*), a 36°*F* TD.

In the first 60 minutes of cooling, the product temperature drops to 50°*F* (10°*C*), now an 18°*F* TD, half the difference between the initial product temperature and the cooling air. This is called half cooling. In the next 60 minutes, the product again cools half the difference between its temperature and the cooling air and drops to 41°*F* (5°*C*), for a 9°*F* TD. It is now at 3/4 cool. After another 60 minutes, it cools to 36.5°*F* (2.5°*C*), a 4.5°*F* TD, and is at 7/8ths cool.

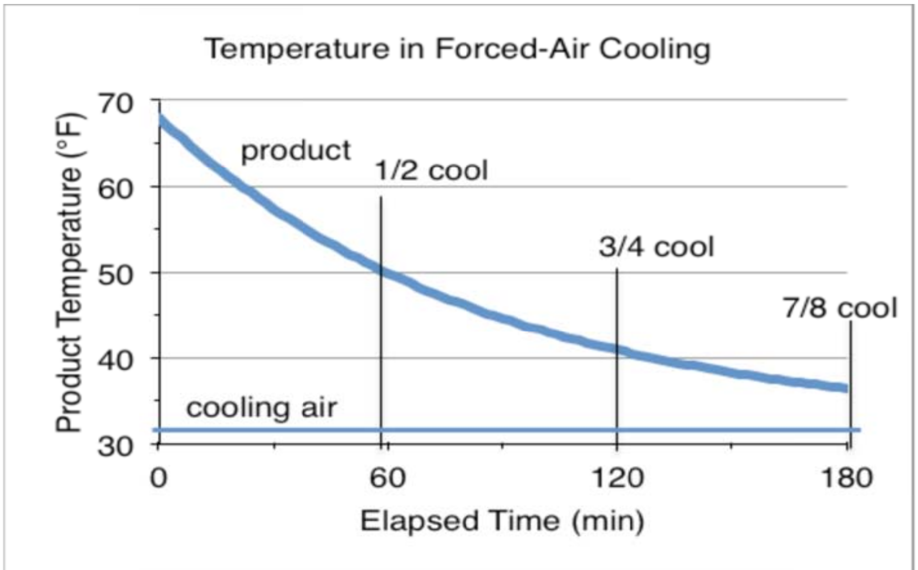

Illustration 1: 7/8ths Cooling Illustrated.
Source: www.PreCoolers.net

This example illustrates a pair of key concepts about precooling. First, the rate of temperature drop is not constant during cooling. The last few degrees of product cooling take much longer, than do the first few degrees. Second, the *first one-third time* of precooling requires much greater cooling capacity – compressors, condensers, and line size/control valves - than does the *last one-third time*. One cannot simply divide the total cooling load, by the time required to precool, and properly select compressor and condenser sizes. Doing so will result in undersized cooling capacity, longer than desired precooling times, and degradation of product quality and shelf-life.

In commercial practice, the product rarely cools to the temperature of the cooling air because it simply takes too long *(point of "diminishing return")*. The air temperature in the cooling room needs to be several degrees cooler than the desired final temperature of the product. For example, strawberry coolers are often operated at about 28°*F* (-2.2°*C*) in order to cool to the fruit to below 33°*F* (0.5°*C*) in a reasonable time. The highest freezing temperature of strawberries is 30.6°*F* (-0.8°*C*), so the fruit is not as close to freezing as the cooling air might indicate. However, to avoid damage the fruit cannot be left on the cooler too much longer than necessary to reach desired temperature *(again, a "smart" controller can be a great benefit.)*

This cooling pattern also means the cooling air must be held at consistently low temperatures near the end of cooling. If it rises because warm fruit is stored in the cooling area, or because an adjacent precooling tunnel starts with its warm fruit when the first tunnel is half- or three-quarters- done, cooling time will increase. If at all possible, cooling and storage operations should be in separate rooms. And adjacent tunnels should be separated by divider walls, even if only by hanging between them sheets of polyethylene or tarp material.

Notice that initial product temperature does not have a big effect on cooling time. In the example, if product comes in at 104°*F* (40°*C*) – a 72°*F* TD - it will require only one additional half cooling period, 60 minutes. This assumes the refrigeration system has adequate capacity to handle the additional heat load from the very warm product. We'll write more about "high-side" (compressor and condenser) sizing in a future piece.

END OF THIS ARTICLE.

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