Global Cooling
Precooling, Postharvest, & Ripening Systems
The Forced-Air Cooling Experts™

Post Harvest Systems
Preserving Freshness

Part 4 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.*

Product Temperature in Forced-air Cooling

by Jim Thompson

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.

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, and longer than desired precooing times.

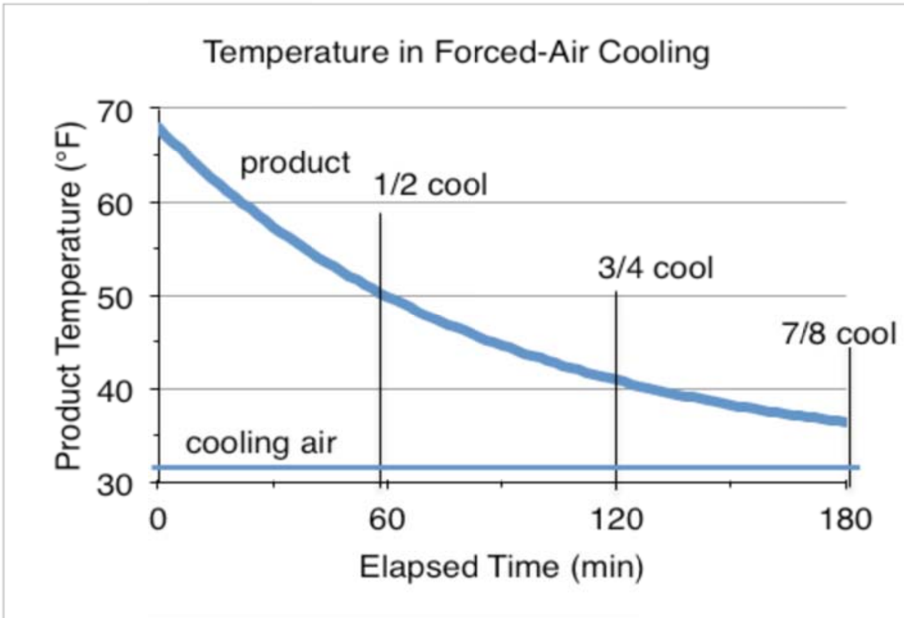

Illustration 1: 7/8ths Cooling Illustrated.
Source: www.PreCoolers.net

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.

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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