Cooling hot pellets critical to quality feed production

Compound feed is often pelleted or otherwise heat treated to form or sanitise the feed. The hot product cannot be stored immediately and needs to be cooled first. This process is more or less taken for granted, but is still an important part of feed processing.

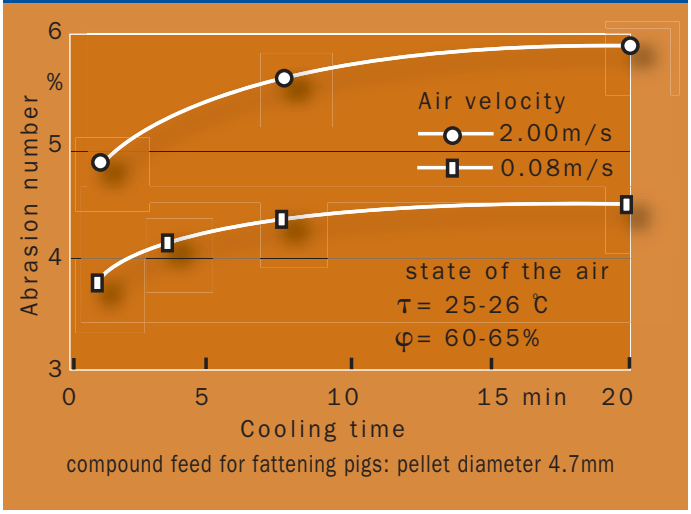
By Dick Ziggers

In pet food cooling and drying are combined and systems are large and very sophisticated. (Photo: ExtruTech)

When pellets leave the pellet mill they are hot (65-85°C) and soft and moist (up to 17% moisture). In this condition they cannot be transported or stored without being damaged. Therefore a cooler is installed in close proximity to the press outlet in which the pellets can harden, moisture can evaporate and temperature can be reduced to about 5° above ambient temperature. Drying of the pellets by one to two percent is a side effect of cooling. The pellets should retain a moisture content of not less than 14%, but also not above this value to assure optimal storage quality.

During transport from pellet press to cooler the hot pellets have to be treated gently, because they are still soft and break easily, which can result in a high percentage of fines. During cooling two processes take place: heat transfer and mass transfer. The heat transfer from the pellets to the air is influenced by the temperature differences at the contact area, the size of the contact area and the heat conducting character of the pellets. Mass transfer means that moisture from the pellets is transferred to the process air. The cooling effect depends on moisture evaporation.

Figure 1 – Effect of air velocity on pellet abrasion



compound feed for fattening pigs: pellet diameter 4.7mm

Cooling time

Cooling should also be a gradual process. If the pellets are cooled too quickly, cracks in the outer layers are formed, which in turn can lead to higher abrasion. Cooling for a too long period also has a negative effect on abrasion, because the pellets become too dry. This also has financial consequences, because, bluntly put, more product is sold and less water, where water is still the cheapest ingredient in the feed. When cooling time is too short the core of the pellet is still warm and pellets are still moist and sticky.

It should be noted that small pellets emit heat and moisture more quickly than large pellets. Even distribution of pellets in the cooler also optimises the cooling process. Airspeed in conventional belt coolers should not exceed 0.5 m/s and in modern counter flow coolers should stay between 0.8 and 1.5 m/s (*Figure 1*). ➢

When airspeed is too high heat is withdrawn too abruptly; moisture evaporation is too low; the outer layer dries too fast and emission of heat and moisture after cooling leads to cracks in the pellets' surface and thus to increased abrasion. When airspeed is too low so is heat withdrawal and moisture removal is too high. *Figure 2* shows a schematic example of the influences on the pellet in a cooler.

Cooler types

In practice two types of coolers are most commonly used: belt coolers and counter flow coolers. On a few occasions some other types of coolers are used, such as for example cascade coolers (*Figure 3*).

A *belt or horizontal cooler* cools the pellets using the cross flow principle whereby incoming air is blown in through a thin layer of product. Cooling at the side of the incoming air is stronger than at the exhaust side. The layer of pellets should be equally spread and not too thickly (belt speed) to avoid irregular cooling. A belt cooler can have one or more decks. A disadvantage of the belt cooler is that a significant amount of air is not used for cooling and is exhausted after passing through a relatively shallow product bed.

The *counter flow cooler* works with an airflow that moves opposite to the product flow. Product continuously moves downward in a product layer while air is sucked through the product layer in an upward direction.

During the time that air and product flow pass each other, they exchange energy and often water. This implies that the coolest pellets on the bottom encounter the coolest air and the warmer pellets on top receive air that has a higher temperature. This prevents thermal shock and the pellets are cooled in a gentle, even and gradual manner.

The Pirouette cross-flow dryer by Dinnissen.
(Photo: Dinnissen)

If coolers need to be renewed and height is not a problem, counter flow coolers are the first choice.
(Photo: Dick Ziggers)

In comparison a counter flow cooler is more efficient than a belt cooler. The volume of air used in a counter flow cooler is lower and can be as little as 60% of the air used in a horizontal belt cooler. In a counter flow cooler there is a large transfer of energy from product to air, which means that the exhausted air has a higher temperature.

Cooling of mash

In the battle against salmonellas, pelleting has been proven to kill these bacteria. In poultry, a large amount of feed is not fed as pellets and much of the feed for laying hens is fed as mash. Here heat treatment systems have been developed to destroy salmonellas with quite some success. However, cooling the heat-treated mash is difficult. A product layer of mash is so dense that it does not let air pass through unless it is fluidised.

Fluidisation in a counter flow cooler should be avoided because it mixes the mash, which is detrimental to the first in - first out principle. Fines can also end up in the exhaust and smear the system. Placing a rotating rake in the cooler can close or level the craters that occur by the air that is pushed through the feed layer, but this is not a complete solution. Dutch cooling specialist Geelen Counterflow has designed a special meal cooler that is designed to operate with a fluidised bed. This double deck cooler operates following a continuous batch principle, where a second cooler deck stores fresh warm product, while the "old" product is properly cooled in the main cooler bin. As soon as the main cooler bin is empty the second cooler is opened and this portion can be cooled.

The use of the fluidisation principle means that almost every component needs to be changed compared to a normal counter flow cooler. Inlet valve, hood, product distributor, bin walls, discharge systems, product sensors, hopper, air fan, ducting, control system; all need to be customised to make a counter flow cooler suitable for meal cooling.

Geelen also uses an automatic airflow control (AFC) valve because accurate control of air volumes is essential to the performance of a meal cooler. This AFC valve sets the exhaust system to the exact correct air volume that is required for cooling or drying of a particular product. This also means remote controlled increase or decrease of air volume when more or less drying or cooling is required.

Equally important is the AFC's ability to stabilise the chosen air volume independent of increases or decreases in bed depth. Without such a system any changes in bed depth (because of filling or emptying) would result in changes in pressure drop, causing the air fan to produce more or less air volume. This in turn could cause uneven cooling or drying. As with all coolers, the exhaust air needs to be cleaned by e.g. bag filter or a cyclone with or without a wet scrubber. In cases where products pose a dust explosion risk, open cycle systems featuring pressure shock resistant components or alternatively semi-closed cycle, self-inerting layouts can be considered.

Special cooler

A sophisticated cooler is the Pirouette® cross-flow dryer concept of Dinnissen to cool and/or dry for example extruded products. The system is based on first in - first out principle, with a fully separation of batches/layers and a vertical airflow, in opposite direction to the product flow. The product is spread out on grid-plated troughs; the height of the product layers is formed by a special spreader-device, which is quite unique and guarantees a regular bed over the whole surface, so that there are no dead zones in the decks. The first deck works as a "flash off" and will load the following bed in several times.

Air temperature and air humidity is PLC controlled and the flow of the drying air is mainly controlled by the specific design of the troughs and is less dependent on the height of the product layers. The several decks make it possible to create adapted atmospheres, according the statue of the product (temperature, humidity). ●

Figure 2 – Schematic description of the crack formation at the dried periphal zone of a pellet

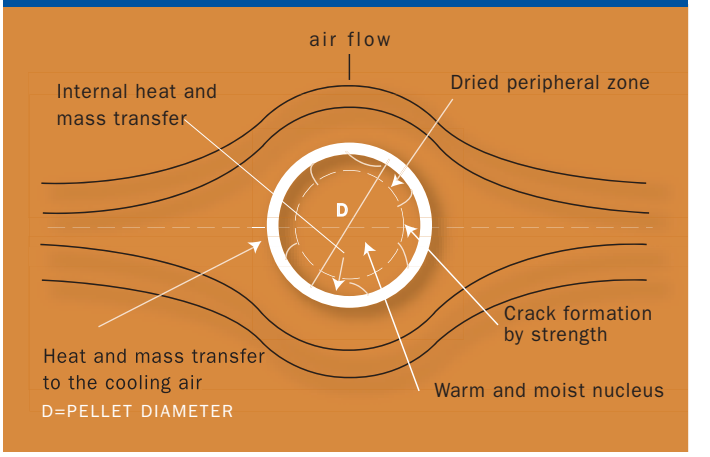


Figure 3 – Principles of heat and mass transfer