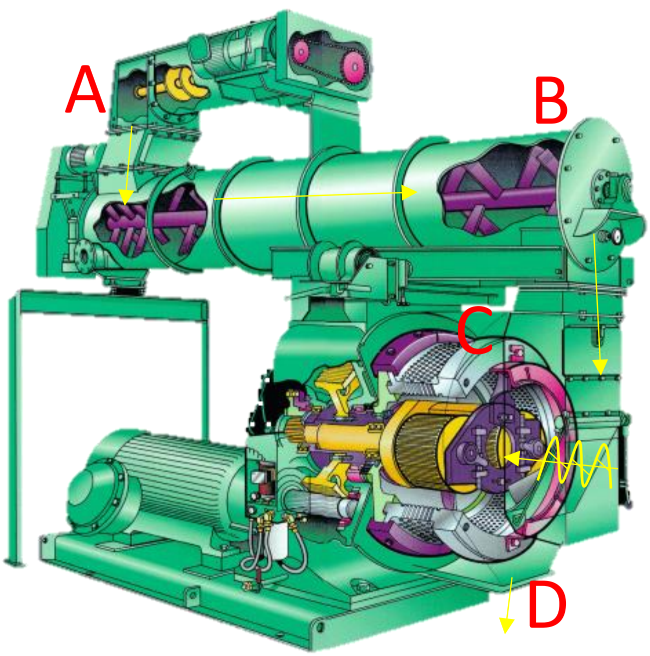
Pelleting

Pelleting swine feed provides many benefits from improved palatability and flowability, to decreased feed wastage, reduced ingredient segregation and destruction of pathogens (Behnke 1994; Figure 1). While pelleting comes at an additional cost of approximately $5 to 6 per ton, the benefits can be realized with improved average daily gain and feed efficiency if pellet quality is maintained. There are numerous factors that impact the pelleting process from diet formulation, pelleting conditions, and specific pellet mill components. Factors that influence percent fines at the feeder include ingredient characteristics, the conditioning process, pellet mill configuration, pellet cooling and transportation.

Figure 1. Feed flow through pellet mill (CPM)

A. Mash feeder
B. Steam conditioner
C. Pellet die
D. Pellet exit to cooler



Monitoring and data collection during the pelleting process

Steam conditioning

Mash feed is steam conditioned prior to forming pellets to increase die lubrication and soften feed particles to increase binding capacity. The process of conditioning is determined by the amount of time feed spends in the conditioner and steam quality. The way in which feed moves from the feeder through conditioner is determined by paddle tip angle and speed. The conditioner should be evaluated weekly by cleaning and examining feed build up more frequently, depending on pelleting tonnage. A continuous flow of feed to the conditioner is important for equal distribution of steam. Monitoring temperature, conditioner retention time, steam quality and conditioned mash moisture throughout the conditioning process will equip mills with the ability to adjust for improvements in pelleted feed quality and pellet mill throughput.

Mash conditioning targets

When conditioning mash feed in preparation for pelleting, some useful targets are 17 to 18% total moisture when mash feed hits the die and 180 to 200°F conditioning temperature for typical corn-soybean meal-based diets. Lower conditioning temperatures are needed to pellet more complex nursery diet formulations but will increase frictional heat, require more energy, decrease throughput, and increase die wear. For example, nursery pig diets with high inclusions of whey included would need to be pelleted at a lower temperature (about 145°F) than a corn-soy finishing pig diet (about 185°F +). Increasing the conditioning temperature will decrease the hot pellet temperature because there is less frictional heat across the die with steam acting as a lubricant.

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- In general, for every 25°F temperature increase there is 1% moisture added to the feed in the conditioner. For example, if the target conditioning temperature is 190°F, the mash temperature in the winter is around 40°F the change in temperature would by 150°F or 6% added moisture. In the summer, mash temperatures can be about 90°F making the change in temperature 100°F or 4% moisture. Therefore, if initial mash moisture is 12%, 18% and 16% moisture will be achieved by steam conditioning in the winter and summer, respectively. Therefore, the temperature of the initial mash will determine final conditioning temperature and final moisture content of the feed. It has been found that total moisture content above 18% can cause pellet mill plugging. However, this will depend on pellet mill configuration.

Achieving conditioning temperature

Conditioning temperature should be achieved by a steam regulator and flow control valve. A steam regulator (i.e. cospect valve) will regulate the pressure at the flow control valve. The flow control valve will regulate the amount of steam in the conditioner.

Conditioner retention time

The conditioner retention time is influenced by conditioner length, pick angles and speed by use of variable frequency drives, based on production rate. Longer conditioner retention times can improve pellet quality by increasing heat and moisture absorption but decrease pellet mill throughput. The length of conditioner retention time is determined by the ingredients included in the diet formulation and their ability to absorb water. Determining conditioner retention time is important to be able to optimize throughput and pellet quality. Retention time for a typical corn-soybean meal-based diet should be about 30 to 45 seconds. While longer retention times can improve pellet quality this can also potentially reduce some nutritional value and increase cost of pellet mill throughput. A longer conditioner retention time may be required for drier diet formulations. High moisture diets may require a shorter conditioner retention time. Longer conditioner retention times can be beneficial at lower conditioning temperatures, allowing more time for feed particles to absorb moisture. A typical corn soybean meal-based finishing diet will require a longer conditioner retention time than a nursery diet containing large amounts of dried milk products.

Measuring conditioner retention time

There are 3 options when considering measuring conditioner retention time: 1) amp load, 2) corn/dye method, or 3) weighing entire conditioner contents (Stark et al. 2020). The amp load method involves stopping the feeder and watching how long it takes for the pellet mill motor load to drop. The whole corn/dye method adds whole corn or a colored dye to the end of the feeder then samples are collected at the inspection door at timed intervals. To weigh the entire contents of the conditioner, the conditioner must be under full load and either vacuumed out or collected into plastic tubs. Then conditioner retention time can be calculated:

$$Conditioner\ retention\ time\ (s) = \frac{Amount\ of\ material\ in\ the\ conditioner\ (lb)}{Pellet\ mill\ prodution\ rate\ (lb\ per\ hour)} \times 3600s$$

Steam quality

Steam quality is defined as the percentage of steam in the vapor phase. Poor steam quality (about 80% vapor) will decrease the conditioning temperature needed for 1% added moisture by about 5°F. Higher vapor steam, about 97% vapor, means higher quality steam. Steam quality is preserved by condensation traps that remove water and impurities as steam travels through insulated pipes into the conditioner. Traps should be cleaned weekly. Excess steam condensation will introduce too much moisture into the mash feed, causing rolls to slip on the die surface, pellet mill plugging, or decreased pellet durability.

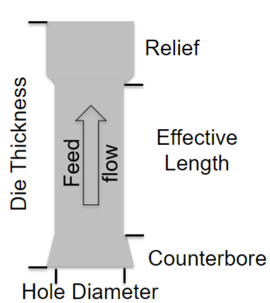
Dies

Die specifications will determine the diameter of the pellet and the amount of time that it is under compression. This is the effective length (thickness) divided by width (hole diameter) or length: diameter (L:D) ratio (Figure 2). The higher the L:D, the more pellet die resistance of feed moving through the hole.

Choosing a die type depends on overall pelleting objectives. Options include alloy, stainless and high chrome, all of which provide different levels of anti-corrosion and resistance. Carburized alloy dies are breakage resistant and should be used with higher mineral feeds and more typical for large-hole cubed dies. Carburized stainless-steel dies provide the best pellet quality over time with moderate abrasive material with the least amount of corrosion (Turner et al., 2014).

- To monitor die performance, tons per die, hours of use, and die specifications should be recorded with each pelleting run. Higher throughput pellet mill dies should be inspected weekly checking for uneven die wear. Uneven die wear can be caused by uneven feed distribution or presence of tramp metal. Indications that a new die is needed include - the rolls no longer make any contact with the die, poor pellet quality with excessive fines, or the die is damaged. Prior to die placement, bolts and clamps should be inspected and replaced if the die is new. After each run, dies should be inspected for tramp metal to protect the die from corrosion.

Figure 2. Die hole effective thickness used to determine L:D ratio



Pellet cooling

The goal of pellet cooling is to decrease the moisture content added during pelleting to equal or less than initial mash moisture content. This is a dynamic process that involves heat and mass transfer moving from higher to lower until a shared equilibrium is established between the air and pellets (Figure 3). Air flow, feed bed depth and uniformity, air and pellet temperature, relative humidity, pellet size and density, moisture content, pellet quality and time spent cooling will determine rate and uniformity of cooling (Stark, 2012b). Creating an even bed depth is perhaps the most overlooked aspect of pellet cooling (Figure 4). Pellets should be evenly distributed inside the cooler for uniform air flow and drying capabilities. Thicker diameter and density pellets require a longer cooling time and air flow to allow moisture to migrate to the surface for drying. Accumulation of fines in the cooler will reduce airflow by pulling fines into air flow ducts, therefore duct work, fans and belts should be inspected in cleaned weakly. A sample of cooled pellets should be evaluated weekly to determine if pellets are obtaining equilibrium moisture via dry matter analysis.

Figure 3. Counter flow cooler function (From Tico)

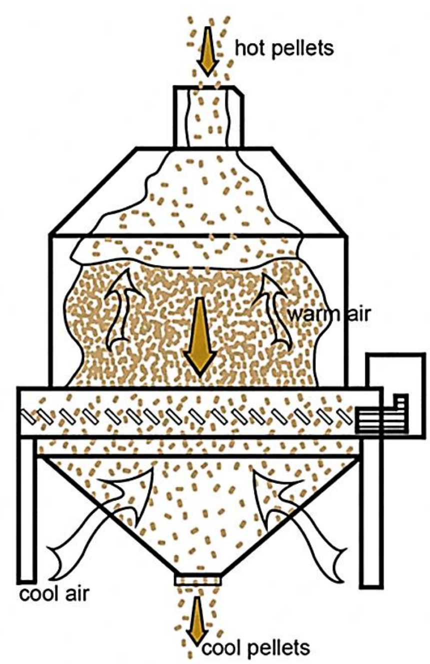
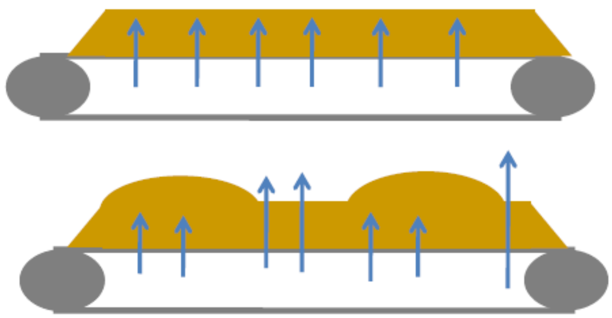


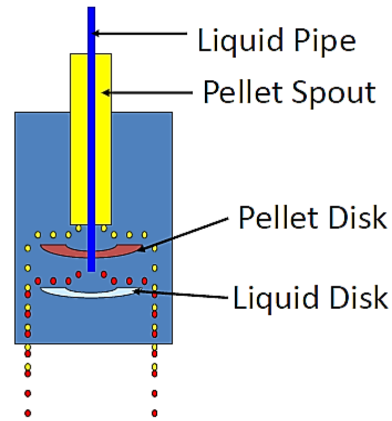
Figure 4. Cooler bed depth illustration



Post-pellet liquid application

Typical ingredients used in post pellet liquid application (PPLA) include fat and enzymes that are not thermostable. In general, the maximum amount of fat that can be added to feed is 6%. Fat can be added at about 1% or less in the mixer to maintain pellet quality. Additional ways to add fat include spraying onto hot pellets leaving the die or after cooling. Liquid ingredients can be applied via spray nozzles or spinning discs (Figure 5). The goal of a PPLA system is to apply an accurate amount of liquid by weight to the pellets with a 360-degree uniform coating of material. Challenges with PPLA systems include accurate ingredient metering, obtaining uniform distribution, and an even flow of feed. Liquid meters should be checked quarterly for accuracy which can be accomplished with a bucket test. To perform bucket test 1) Tare an empty, clean bucket on a scale, 2) weigh out expected liquid amount, and 3) weigh buckets with measured liquid on scale to check expected liquid addition. Liquid application can occur either after the pellet die or after pellets have been cooled. When greater than 3% of liquid is applied prior to cooling the liquid can be drawn off the surface of the pellet and end up in the cooler or cooler air system because there is little time for ingredient absorption (Stark, 2016). When applying liquid to already cooled pellets, a stand-alone system of a sprayer in a screw or conveyor system is an option. Even so, a continuous flow of pelleted product is required for even and accurate application from either system. Depending on pellet mill production, weekly cleaning and maintenance of the system should be scheduled to ensure appropriate application.

Figure 5: Post pellet liquid application thru disk (from Stark, 2018)



Testing Pellet Quality

After cooling, pellets are run through several feed lines and transported to farm sites which can be an abrasive process which influences what pellets look like at the feed mill compared to the feeder. To determine pellet quality at the feeder the combination of pellet fines at the feeder and pellet durability index (PDI) at the feed mill are used. Percent fines is determined by the number of fines sifted from pellets. To determine PDI, a tumble box or a pellet durability tester from Holmen series can be used. Comparing samples from the farm and feed mill can determine the adjustments needed. These adjustments include modifying the standard method or the amount of time pellets need to be in the chamber of the Holmen pellet tester. Additionally, options for in-line pellet testing for Holmen series pellet testers are available. Prior to analysis, all samples should be riffle divided until the desired test weight is achieved.

Standard method

Fines should be sifted off by using the corresponding sieve stack from a sample of cool pellets (Figure 6; Table 2). Sifted pellets should be split using a riffle divider and 500-g weighed for analysis. Place the 500-g sample in a designated chamber of the tumble box and run for 10 minutes. After tumbling, the sample should be collected from the compartment and sifted using the same sieve as used previously. Weigh the remaining sifted pellets to calculate PDI, by dividing the final sample weight by the initial sample weight and multiply by 100.

Figure 6: Tumble box pellet tester, 4 compartments.

Standard method (modified)

The same method should be used as above, however with the modification, the test becomes more abrasive. Once the 500-g sample is placed in the designated chamber of the tumble box, three ¾ -inch hexnuts should be added. The sample along with the hexnuts should be tumbled for 10 minutes and remaining procedure from the standard method completed.

Holmen method

Fines should be sifted off by using the corresponding sieve stack from a sample of cool pellets (Figure 7; Table 2). Sifted pellets should be split using a riffle divider and 100-g weighed for analysis. The 100-g sample is then placed into the hopper of the Holmen 100 and a Brawny paper towel should be placed between the chamber and the lid (NHP 100 series). Then the desired run time can be selected of 30, 60, 90 or 120 seconds. Once completed, the sample is removed from the hopper and weighed. The PDI is then calculated by dividing this final sample weight by the initial sample weight, and multiply by 100.

- While there is no universal pellet durability target, decreasing the number of fines at the feeder should always be the goal.

Figure 7. Holmen NHP 100 portable pellet tester.

Summary

In summary, there are numerous processing parameters that influence both the pelleting process and pellet quality. While there is an added cost and processing step to pelleting swine diets the payout can be seen in performance if pellet quality is upheld. Factors such as formulation, equipment design, and manufacturing parameters not only determine pellet quality but also pellet mill production rate and energy consumption. There must be a balance between added costs at the feed mill compared to costs at the feeder.

Additional resources

Feed Pelleting Reference Guide

- https://www.feedstrategy.com/feed-pelleting-reference-guide/

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