Bin Level Indication Applications in Feed Milling

Introduction (Wikipedia)

Feedstuffs are feeds for domestic animal consumption blended from various raw materials and additives. These blends are formulated for the target animal and in accordance with standards and various brand modifications. They are manufactured as meal type, pellets or crumbles. One of the more popular is feed pellets and we will highlight that manufacturing process and illustrate the use of bin level indicators within the feed mill.

Feedstuffs can be complete feeds that provide all the required daily nutrients, concentrates that provide a part of the daily requirement or supplements that just provide additional micronutrients and other requirements for the animal, such as vitamins or minerals.

The history of industrial production of feedstuffs is said to be traced back to the late 1800's, which is around the time that advances in human and animal nutrition was able to identify the importance and benefits of a balanced diet. Corn gluten feed was first manufactured in 1882, while the leading global feed producer (Purina) was established in 1894 by William Danforth. Cargill, which was mainly dealing in grains since its inception in 1865, began feed production in 1884. The feed industry expanded rapidly with Purina leading the way and expanding operations into Canada in 1927 and that feed mill is still in operation today (March 2007). In 1928 the feed industry was revolutionized when the first pelleted feeds, Purina Checkers was introduced.

Ingredients: The main ingredients in commercial feedstuffs are the feed grains, including corn, soybeans, sorghum, oats and barley. Corn production was valued at $25 billion in 2003. Soybean was valued at $17.5 billion, and 60% of Sorghum production (valued at nearly $1 billion) is used as livestock feed. Oat production was valued at about $218 million.

The production and sale of premixes has become an industry within the feed industry. Premixes are comprised of micro-ingredients such as vitamins, minerals, chemical preservatives, antibiotics, fermentation products and other essential ingredients that are purchased from premix companies. With the availability of premixes farmers can blend their own feed and be assured that their animals are getting proper nutrition while using the farmers own grain.

Pelleted Feed Production

Whether the end product is for cattle, horses, pigs, dogs or cats, pelleted feed compound is popular and represents a substantial part of the feed manufacturing industry. An example of the feed pellet production process is shown in Figure 1.

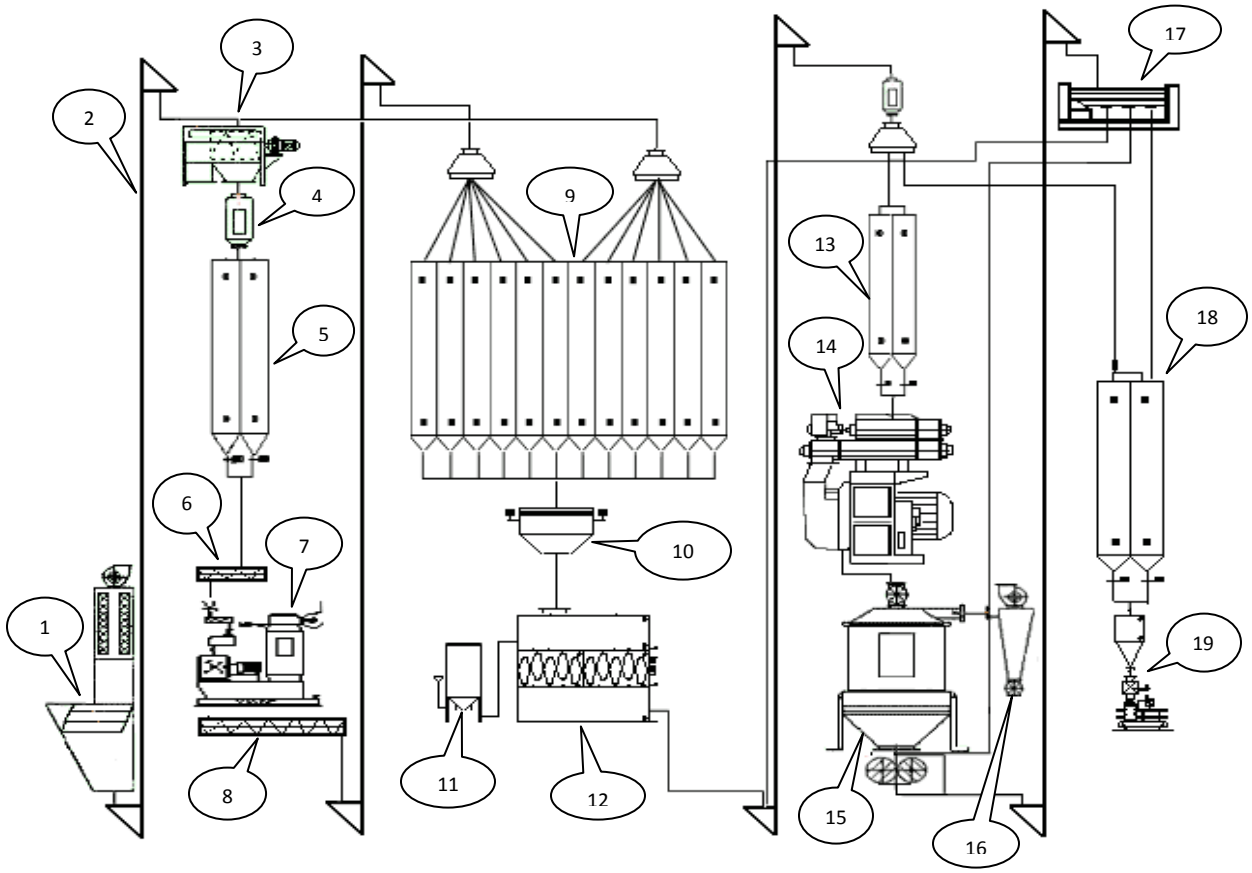

Figure 1: Pelleted feed manufacturing process (courtesy feedmachinery.com)

Balloon #	Description
1	Material inlet hopper where raw material comes into the feed mill. Multiple raw material hoppers can exist at various points in the mill. Dust collector located just above inlet hopper.
2	Bucket elevator. This is the conveyance device used to move material up heights to the top of bins and silos. Used in a variety of locations in the mill. Multiple elevator legs will exist.
3	Cleaner. This equipment will remove rough impurities from raw material ingredients in the beginning of the feed manufacturing process.
4	Inline magnet. This equipment is used to remove metal (ferrous) from the incoming raw material. There may be multiple magnets within the process to ensure that ferrous metal is completely removed from raw materials and ingredient materials into the finished feed.
5	Raw material bulk storage bins before grinding in hammer mills.
6	Screw feeder used to convey material into hammer mill from bins.
7	Hammer mill used to grind raw materials into small particles for further processing.
8	Screw feeder.
9	Ingredient storage bins. Automatic batching system used to weigh materials in proportion into mixing system.
10	Batching scales.
11	Liquid ingredient tank.
12	Mixer for mixing all feed ingredients together.
13	Bulk storage bins for mixed feed material located above pellet mill.
14	Pellet mill forms feed material into raw feed.
15	Cooler. Cools raw pellets to proper temperature for further processing.
16	Cyclone collects dust from cooler.
17	Screener used for grading finished feed according to size.
18	Finished feed product bins for storage before loadout or bagging.
19	Automatic bagging system with feed hopper.

Table 1: Description of process equipment in Figure 1. Yellow highlight indicates where bin level indicators can be found.

Bin Level Indicator Use

Referring to Figure 1 and Table 1, there are several locations where bin level indicators are used to help ensure smooth and continuous production of compound feed within the feed manufacturing process. These are summarized as follows:

Inlet Hopper: The inlet hopper accepts raw material delivered from trucks. The hopper is typically located below ground with the inlet at ground level. This hopper will feed the bottom of a bucket elevator leg that transports the raw material to the cleaning process that screens and removes magnetic ferrous metal particles before the material is placed in raw material bins ahead of the grinding process. Many times a bin level indicator is used to indicate an empty or full condition in the inlet hopper. This aids in elevator control and can keep from overfilling the hopper if a blockage occurs.

The most notable choice for bin level indication in inlet hoppers is the pressure-sensitive diaphragm switch. These units are mechanically activated by the pressure exerted on a diaphragm by the presence of material. An electrical switch, located behind the diaphragm will open or close in response to the weight of the material, or absence of the material, on the external diaphragm. These devices are cost effective, around $160-200 and up. Those that carry a hazardous location for grain dust applications are $200+. Diaphragm Switch type bin level indicators are excellent devices for dry free-flowing materials that are not sharp and are moderate to small particle size.

Dust Collector/Cyclone: Some dust collectors have hopper bottoms where the dust is collected and drawn off. In these types of dust collectors or even cyclones (serve the same purpose) a bin level indicator may be employed to prevent material backup into the collector or cyclone by detecting a high level condition and signaling to the dust collector control that an emergency condition exists.

In this application there are three typical choices of bin level indicator technologies, e.g. Rotary Paddle, RF Capacitance/Admittance and Vibrating Element. The choice may depend on the typical bulk density and cost sensitivity. Very often the Rotary Paddle style device is chosen if the dust collected is 5-10lbs/ft^3 or greater. These devices are cost-effective, typically being purchased for $200-300, even with the hazardous approvals for grain dust environments. If a solid state technology is preferred, then the Vibrating Element or RF Capacitance/Admittance devices may be favored, however, a brand providing low density and low dielectric sensitivities is needed. These will cost from $400-600+ and may make their choice over a Rotary paddle bin level indicator an expensive proposition. However, they will provide good reliability and are solid state with no moving parts.

Bulk Storage, Ingredient and Finished Feed Bins: The modern feed mill can be represented by the one illustrated in Figure 2. In this example (Todd & Sargent) there are nineteen ingredient storage bins totaling 3900 tons of material, 4 pellet mill surge bins totaling 290 tons and 22 bulk load-out bins totaling 3000 tons. The mill can pelletize 180 tons per hour of feed.

Figure 2: Sanderson Farms feed mill courtesy Todd & Sargent website

The use of bin level indicators through these ingredient storage bins and also within the raw grain bins is common for high level detection, some for low level detection and also for inventory monitoring.

The reliability of the bin level indicator for high level is important to the production operation. These devices are used to signal the mill control system that the bins are full and they also help protect the mill from overfilling the bins, which helps eliminate cleanup costs and keeps production running. Typically, high level indicators are of the Rotary Paddle style. In addition, RF capacitance sensors can be used. However, the Rotary Paddle bin level indicator has been standard equipment in mill design in these applications due to their cost effectiveness and long term reliability.

In this high level detection application the Rotary Paddle units are top mounted and incorporate the power pack, flexible shaft coupling, extension shaft, extension guard and paddle. The length of the extension shaft and guard are sized to extend the paddle to the desired detection point from the mounting location on top of the bin. Extension lengths are not usually greater than 6 or 7 feet, however, they can go up to a maximum of 12 feet with Rotary Paddle units. If a much longer extension length is needed, an alternate technology, such as RF capacitance or vibrating element, should be considered. RF capacitance/admittance sensors with cable probes can extend the sensing point up to 50 feet, while the cable probe version of a vibrating element level sensor might extend the sensing point up to 65 feet. See Table 2 for a comparison of these three technologies in this application.

Technology	Max. Ext. Length	Max. Standard Process Temp.	Bulk Density Range	Cost (10ft Ext. Length)	High Level	Low Level
Rotary Paddle	12feet	200 F	5-100 Lbs/ft^3	$320	✓	✓
RF Capacitance/Admittance	50ft	180 F	15-90 Lbs/ft^3 (Depending on Dielectric Constant)	$540	✓	✓
Vibrating Element	65ft	230 F	3Lbs/ft^3	$700	✓	CF

Table 2: Comparison of bin level technology for bulk storage and ingredient bins

Inventory monitoring of the ingredient bins and grain storage bins is typically accomplished using smart weight & cable technology. The narrow size of ingredient bins and the dust found within many of the bins makes it very difficult for non-contact through-air technology. The beam angle on ultrasonic and radar devices can create false reflections or echoes. The dust can blind ultrasonic sensor technologies. In addition, the smart weight & cable sensor is the most cost-effective and can range up to 150 feet in distance measurement. When needed, this simple and reliable technology is a good choice. Let's compare the technology, shown in Table 3 below.

Technology	Practical Max. Range	Sensitive to Dust	Sensitive to Bin Size	Cost	Max. Process Temp.
Smart Weight & Cable	150feet	No	No	$1400/bin	300 F
Ultrasonic	80feet	Very	Very	$1600/bin	180 F
Radar	80feet	Somewhat	Little	$2500+/bin	260-400 F
Laser	80-100feet	Yes	No	$2500+/bin	150 F

Table 3: Comparison of continuous level technologies for bin inventory monitoring

Screw Feeders: While modern feed mills may incorporate pneumatic conveying along with screw conveying, the later remain commonplace in all feed mill designs. Bin level indicators have a special application in the screw feeder (a.k.a. screw conveyor) to detect a material backup within the conveyor itself. This application requires a low-profile or non-invasive device because of the close proximity of the turning auger. For this reason a diaphragm switch is typically used. These devices are easily installed in the cover of the conveyor, possibly over the discharge area, and if the material backs up into the conveyor for any reason and presses against the external diaphragm, the microswitch under the diaphragm will reverse state and indicate a material backup condition.

Pellet Mill: The process of pelleting is a primary component in feed milling. This process element consists of forcing a soft feed through holes in a metal die plate to form compacted pellets, which are then cut to a pre-determined size. Each bite of feed pellet will have the same designed formulation ensuring that all livestock are fed as intended.

A typical pellet mill includes a feeder, conditioner, pelleter, speed reducer, motor and base. The feeder is most often a screw or auger design and the mixed ingredients are feed by the feeder into the conditioner where liquids such as water (sometimes in the form of steam) and molasses can be added to improve pelletability of the mix. The use of steam aids to soften the feed material and partially gelatinizes the starch content of the ingredients, resulting in firmer (more water stable which is important for aquafeed) pellets.

From the conditioner the feed falls into the center of the pelleter itself where two or more rollers and feed ploughs push the material through the holes in the die plate. Usually the die plate rotates and stationary knifes cut the pellet to the desired size.

A bin level indicator is used to detect a high level condition of material entering the pellet mill. This can be done in the feeder to the mill or within the material flow in some mill designs. Typical technologies employed include the pressure sensitive diaphragm level switch and the Rotary Paddle bin level indicator, both as previously discussed.

Cooler: Feed pellets exit the pelleting process at close to 200 F (88 C) in temperature with perhaps 17-18% moisture content. The temperature of the pellets must be reduced to room temperature quickly and the moisture reduced to a more nominal

Figure 3: Cooler featured by Bliss Industries, Inc.

10-12% or less for proper storage and handling. There are two types of coolers or dryers, horizontal and vertical. Bin level indicators are more commonly found in certain coolers, such as the one shown in Figure 3 on the previous page. In the application shown, bin level indicators can be located to; 1 provide fail-safe high level protection against overfilling, 2 monitor low level and intermediate points depending on the application. In these cooler applications the Rotary Paddle bin level indicator is most commonly used due to cost efficiency and proven long term reliability in the application.

Conclusion

Bin level indicators are an integral part of the operation of a feed mill and have been for decades. Whether protecting against silo overfilling, controlling conveying operations or monitoring inventory in ingredient, loadout or raw material bins/silos, they are an important part of the feed mill operation. Rotary Paddle, Weight & Cable, Diaphragm Switch and some RF Capacitance/Admittance technologies are most common within the modern feed mill today.