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THE RECIPE FOR PERFECT FOOD

coperion K-TRON

Technical Paper

Evaluating the True Cost of Your Pet Food Ingredient Feeder

An efficient feeding system can offer significant return on investment thanks to higher accuracy and better control, despite the higher initial capital investment.

Introduction

Single and twin screw feeders, as shown in Figure 1, are often used as the dispensing and feeding method of choice for pet food ingredients or premixes. Both gravimetric and volumetric devices are used for a variety of pet food unit operations including batching operations to mixers, and feeding to size reduction mills. In addition, high accuracy gravimetric feeders are often called the "heart" of the continuous extrusion process. Base prices of most standard feeders can start as low as $6,000-10,000 for volumetric applications. However, it is important to note that a wide variety of options exist for powder screw feeders, each of which result in a variety of price points. This article will outline several of the options available for pet food feeder applications and also define the process advantages when considering these options.

Figure 1: Twin and single screw feeders are used for a wide variety of raw materials

Volumetric or Gravimetric

As stated above, screw feeders are available in both volumetric and gravimetric loss-in-weight (LIW) designs. In general, due to the added cost of the controls and weigh scale or load cells, a gravimetric feeder will be at a higher price level than a volumetric feeder. A volumetric feeder feeds a certain material volume per unit of time (such as cubic feet or liter per hour) to a process. The bulk material is discharged from a hopper with a constant volume per unit of time by regulating the speed of the feeding device. In general, the feeding accuracy of any volumetric feed device is dependent upon the uniformity of the material flow characteristics and the bulk density. (Figures 2 and 3 illustrate the volumetric versus the gravimetric feeding principle.)

Dependent upon the applications, volumetric feeders can sometimes be the technology of choice. For example, in many size reduction or some blender filling applications, volumetric feeders are used in lieu of gravimetric when consistency of volumetric feed is important, and high accuracy of mass flow is not a concern. In order to optimize the consistency of the volumetric feed, however, it is important to investigate feeder suppliers which incorporate feed screw modulation into their control algorithms. Feed screw modulation is a method of minimizing the pulsations which may occur as material is discharging from the screw, thus optimizing the consistency of flow.

Unlike the volumetric screw feeder, a LIW feeder is a gravimetric feeder that directly measures the material's weight to achieve and maintain a predetermined feed rate that is measured in units of weight per time. The bulk material is discharged from a hopper by weighing the material being fed and regulating the speed of the feeding device. The weighing system with control compensates for non-uniform flow characteristics and variations in bulk density, and therefore provides for a high degree of feeding accuracy. The feeders control and dictate the total mass flow to the process below. For these reasons, gravimetric feeders are the feeders of choice for continuous processes such as pet food and pet treats extrusion and are often called the "heart" of the continuous process.

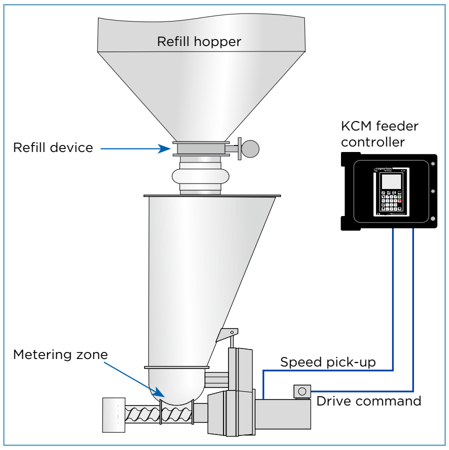

Figure 2 - Volumetric feeder principle: A volumetric screw feeder feeds a certain material volume per unit time to a process.

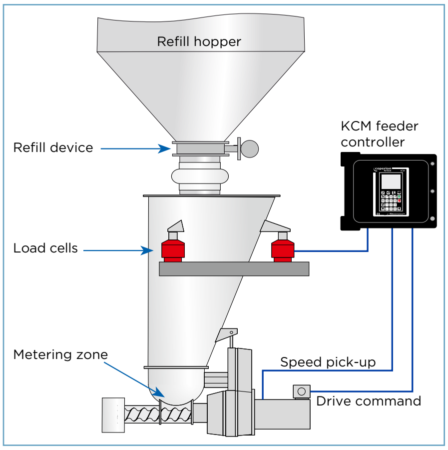

Figure 3 - Gravimetric loss-in-weight feeder principle: A loss-in-weight (LIW) feeder is a gravimetric feeder that directly measures the material's weight to achieve and maintain a predetermined feedrate that's measured in units of weight per time.

It is important to note that if the material being fed has a tendency to bridge or create ratholes in a feeder hopper, a LIW feeder will detect these occurrences quickly, due to the lack of weight loss in the hopper. A volumetric feeder, on the other hand, will continue to run at the speed set, thus possibly resulting in a period of time where little or no material is fed to the process below. For this reason, even in applications where a volumetric feeder may be suitable, the added cost of a LIW feeder may be considered a profitable investment ensuring process reliability and end product quality.

Load Cell Accuracy and Resolution

Any LIW process controller requires accurate high-speed measurement of material weight changes in order to provide optimal feeder control and performance, especially on a second-to-second basis. The weighing system must also be able to filter out erroneous measurements due to in-plant vibrations or disturbances and be stable over changes in process room or process material temperatures. The higher the resolution of weight measurement and the faster those weight measurements are taken, the better the information that will be provided to the control algorithm and the better any vibration filtering algorithm will work. In addition, almost all weighing systems provide temperature compensation. The exact warranted temperature range should be verified, as this can affect the long term stability of the feeder performance.

When evaluating gravimetric feeder technologies, it is important to understand both the weighing technology resolution as well as the responsiveness of the control system. Both of these important attributes will greatly affect the resultant accuracy of the feeder, which in turn can have a significant effect on overall ingredients dispensed and the resultant costs and/or the quality of the end product. These attributes are also very significant for low mass flow rates, such as those which may apply for low formulation percentage ingredients such as vitamins or probiotics and also for any required high second-to-second accuracy.

Materials of Construction and Surface Finish

Most feeders for pet food applications include stainless steel for all product contact surfaces, with a preference towards 316 type steel. It should be noted that some manufacturers offer 316L as the standard, due to its higher corrosion resistance, particularly in relation with the cleaning agents used. Surface finishes usually include a minimum of 0.8 micron Ra for all product contact surfaces. It is important to verify with the feeder manufacturer the options available for both surface finish and surface treatments (e.g. electropolishing) as these may be added costs. In addition, it is important to discuss with the feeder manufacturer the flow properties of the materials being fed, and how options on different surface treatments or finishes may affect the flow through the feeder. For example, higher surface finishes (e.g. typically below 0.2 micron Ra) may not improve flow, but may actually impede it, due to the change in surface tension of the stainless steel. In addition, for very poor flowing materials, there may also be options for surface treatments such as PTFE coatings.

Since materials of construction and surface finish standards may differ from manufacturer to manufacturer, it is imperative that the end-user discuss all the options and price levels available. A manufacturer with extensive experience in handling difficult flowing ingredients, like Coperion K-Tron, will be able to easily recommend the best and most cost effective combination for your application.

Single or Twin Screw Feeders

Screw feeders represent the most versatile feeding technology for most bulk solids. Given the material characteristics, a variety of screw configurations varying in both screw pitch and diameter are available to cover a wide variety of feed ranges. In addition, screw configurations can be single or twin screw design, as shown in Figure 4.

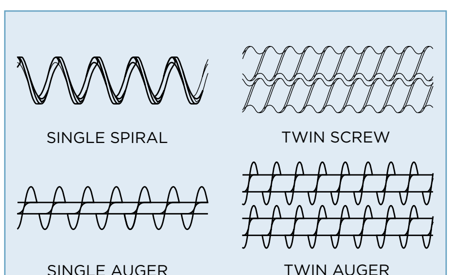

Figure 4 - Basic single and twin screw geometries.

Of special note is the basic distinction between the material handling capabilities of twin screw versus a single screw design. Where two screws intermesh and co-rotate, the result is the formation of relatively sealed, forward moving pockets of material. Thus, the twin screw acts similar to a positive displacement pump and first captures floodable or poor flowing materials, and then forcibly moves them to discharge.

An added advantage is the self-wiping action of the screws that helps to keep the screw surfaces clean and free of build-up. Single screws, whether in a spiral or auger type design, do not possess this type of pumping action, and thus are not recommended or appropriate for floodable or cohesive, poor flowing materials. Due to the high turndown ratio and flexibility of design, screw feeders can also be provided to feed extremely accurately at rates as low as 20 g/h, with screws as small as 12 mm in diameter. These smaller screw feeders, such as the Coperion K-Tron Microfeeder (Figure 5), can be ideal when feeding micro ingredients, such as probiotics or vitamins.

Figure 5: Coperion K-Tron gravimetric Microfeeder K-CL-SFS-MT16 (front) and volumetric Microfeeder K-CV-MT12 CK (rear).

In general, for equivalent required feed rates, single screw feeders will be less in cost than twin screw feeders. However, as stated above, it is important to note the performance improvement which may be resultant in a twin screw feeder, thus resulting in more accurate feeding and overall ingredient cost savings.

Flow Aids for Improved Feeder Performance

It is important to note that the accuracy of any screw feeder is largely dependent upon consistent screw fill. A flow aid device may be required in or on the feeder's hopper to assure that the process material flows into the feeding device as uniformly as possible and to enable a consistent screw fill. Again, the more stable or uniform the material flow is, the easier it is for the weighing and control system to provide optimal second-to-second performance. There are several types of material flow aids available such as:

- **Mechanical hopper agitators** that stir the material and break down any bridging or ratholing of the material. These agitators can include horizontal type configurations mounted by the feed screws to facilitate flow into the screw area, and possibly vertical agitators which provide additional agitation in the hopper above. Typically horizontal agitators are included in the feeder's base price. Vertical agitators often include a separate motor, require additional head-room for the feeder, and represent additional cost. Furthermore they can become a cleaning concern.

- **External vibration on the feeder hopper.** Vibrators can be used as flow aids in hoppers for volumetric feeders. However, in the case of LIW feeders, this vibration can cause interference with the LIW signal if the control system cannot filter out the vibration. In addition, constant uncontrolled external vibration can cause excessive packing of the material within the hopper. Alternatively, there are some new innovative control technologies available which utilize vibration applied to the hopper by an external drive tied directly into the weight system controls. The drive operates at a variable frequency and amplitude based upon the weighing and control system detecting non-uniform material flow by weight. This realtime device activates the external vibration only when there is an upset in the LIW signal, such as in the case of ratholes or material bridges. This technique provides added benefits in that it eliminates head-room and cleaning concerns and avoids compaction of the process material. Only the necessary amount of vibration is applied to the material to assure uniform material flow. Figure 6 shows an example of this external realtime vibration aid, the Coperion K-Tron ActiFlow™. Although adding the ActiFlow may initially increase cost, it will definitely result in a significant return on investment by reducing downtime caused by material flow errors.
- **Feeders with flexible side walls** that gently agitate materials. It should be noted, however, that these are not stainless steel surfaces and may wear, can be easily stained and/or create contamination concerns.

Figure 6: Coperion K-Tron twin screw feeder with ActiFlow™ bulk solid activator. ActiFlow eliminates headroom concerns, reduces cleaning and product changeover time and in turn lowers overall production labor cost.

Overall Ergonomic Design and Accessibility

A variety of feeder design options exist on the market for ease in accessibility. As a minimum, it is important to consider those which incorporate quick release design features including tri-clover clamps in lieu of bolted flanges where applicable, quick disconnects for electrical components, as well as quick removal screw configurations. In addition, feeder designs exist which allow for multiple exchange modules to achieve a variety of feed ranges within the same drive and scale configuration. Figure 7 shows a Coperion K-Tron Quick-Change Feeder.

Figure 7: Coperion K-Tron Quick-Change Feeder QC with exchangeable feeder module.

Wherever possible, re-configuring one feeder to perform the function of two or more is far preferable to the added procurement cost and ongoing time consumed by continually switching over and maintaining multiple feeders.

When discussing overall feeder configurations, there are a variety of important questions to be considered regarding upstream and downstream processes. For example, in the case of continuous LIW feeding, how will the feeder be refilled? Which options are available for the interface between the refill device and the feeder and is it certain that these options will not impact feeder performance? Which options are available for a multi feeder system that will help to make the feeders more accessible? The answers to these questions may affect the recommended feeder configuration as well as the overall cost. Design features such as rotating turntables, specialty roll out carts or tracks, and lift devices will all aid in improving the ergonomics of the feeder configuration as well as total time required for cleaning and changeover. Any small efficiency gained in the cleaning operation will be multiplied through time and by this generate a considerable reduction of the running costs. (*for further information on feeder refill see white paper T-900017 "Smart Refill Technology in Loss-in-Weight Feeding"*)

Method of Cleaning

In addition to the mechanical design features mentioned above, there are a number of features which can be added to the feeder dependent upon the method of cleaning. When considering wet cleaning, for example, it is important to discuss if a wash-in-place or rinse-in-place method of cleaning will help to improve your overall cleaning turnaround times. In these cases, options such as retractable spray ball assemblies and specially pitched frames to allow for drainage can be provided for the feeder, as well as a recommended cleaning protocol to ensure optimal initial wash cycles.

A knowledgable feeder manufacturer can advise design options which can reduce your cleaning and reassembly times.

Summary

The overall design and engineering of a pet food ingredient feeder can include a variety of options which can significantly increase the efficiency of operation. It is important to evaluate these options when evaluating true overall feeder cost from a capital investment perspective as well as overall effect on operating and material costs. Too often the savings and process improvements that an efficient feeding system can produce over time are not considered at the time of purchase, with only the "up front" capital cost of the equipment reviewed initially. For this reason, it is imperative to discuss with the feeder supplier all of the options available in order to truly understand the returns on investment of the feeding technology, as well as ensuring the optimization of its performance.

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