Technical Paper

What Is the Best Pneumatic Transfer Method for My Pet Food Process?

Introduction

Today's pet food manufacturers are constantly searching for methods to improve process efficiency, changeover times, and, of course, ensuring product safety. One of the key technologies which can help address and improve all of these factors is pneumatic conveying, regardless of whether it is for the raw ingredients (major and minors), extruded kibble, or final dried/coated product prior to packaging. Older methods of transferring finished products and even raw ingredients via mechanical and drag conveyors or bucket elevators are quickly diminishing. Pneumatic conveying offers a much cleaner and safe alternative. By properly selecting the best method for the application, a much more cost effective and reliable means of material handling can be achieved. This white paper will outline and define the methods of pneumatic conveying available, with an emphasis on the advantages of each conveying type for a variety of unit operations in pet food processing.

Pneumatic Transfer – Vacuum or Pressure?

Pet food manufacturing facilities will typically include several pneumatic conveying types. The mode of transfer of raw ingredients or final product is dependent upon many process parameters, including material characteristics, distance to be transferred, required rate of transfer, friability of product and/or segregation concerns. In the case of raw material delivery, the type of container in which the ingredient is originally received can also be a factor. For example, majors such as flour and grains are often received by truck or railcar and then stored in silos prior to usage. Pressure Differential (PD) trucks and railcars use positive pressure to unload material, whereas other types of delivery to the blending batching steps can involve either positive pressure or negative pressure. It is therefore important when choosing the conveying method that a full examination of several process parameters be completed, since different options can result in cost savings and efficiency improvements.

Positive pressure systems, (such as that shown in Figure 1), are typically used to convey bulk materials from a single source to one or multiple destinations. This is done by use of a positive displacement blower blowing into material entry points located downstream. These entry points then meter each product into the conveying line by means of a rotary airlock valve which maintains the pressure differential between the ambient atmosphere and that of the conveying line. Material and air blown through the line exit at single or multiple use points where they are separated by means of a filter receiver or cyclone separator, or fed

directly into process vessels, such as that shown in Figure 1. Positive pressure conveying systems are typically used to transport product over long distances and at high throughputs. Applications which involve pressure conveying often include loading and unloading of large volume vessels such as silos, bins, railcars, trucks, and bulk bags.

Conversely, negative pressure or vacuum systems (such as that shown in Figure 2) are generally used for transporting material from multiple sources such as storage vessels, process equipment, bulk bags, trucks and railcars, to individual or multiple destinations and are used for lower volumes and shorter distances. Negative pressure is created by a positive displacement vacuum blower located at the downstream end of the system. Material can enter the system via bag dump stations equipped with ro-

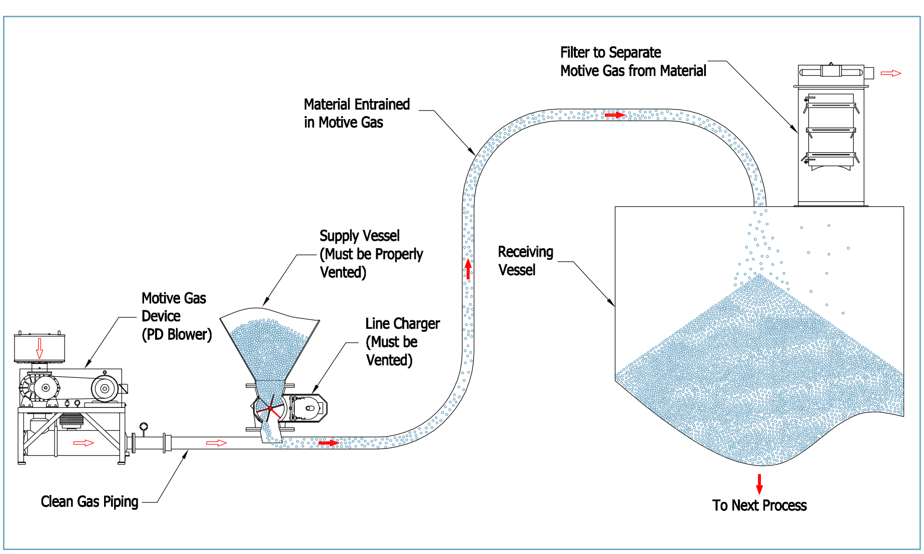

Figure 1 - Typical dilute phase positive pressure system

Photo 1 - Sanitary Design Bag Dump Station tary airlock valves (see photo 1), handheld pickup wands, and pickup hoppers. Material exits the system through filter receivers that separate the material from the conveying air directly above process equipment, surge hoppers, storage vessels or other discharge points. One of the advantages of vacuum systems is the inward suction created by the vacuum blower and reduction of any outward leakage of dust. This is one of the reasons why vacuum systems are often used in higher sanitary or dust containment applications. Another advantage of vacuum systems is the simple design for multiple pickup points. It should be noted, however, that the distances and throughputs possible with a vacuum system are limited due to the finite level of vacuum that can be generated.

The table below outlines just a few of the comparative differences between choosing positive pressure or negative (vacuum) pressure conveying systems.

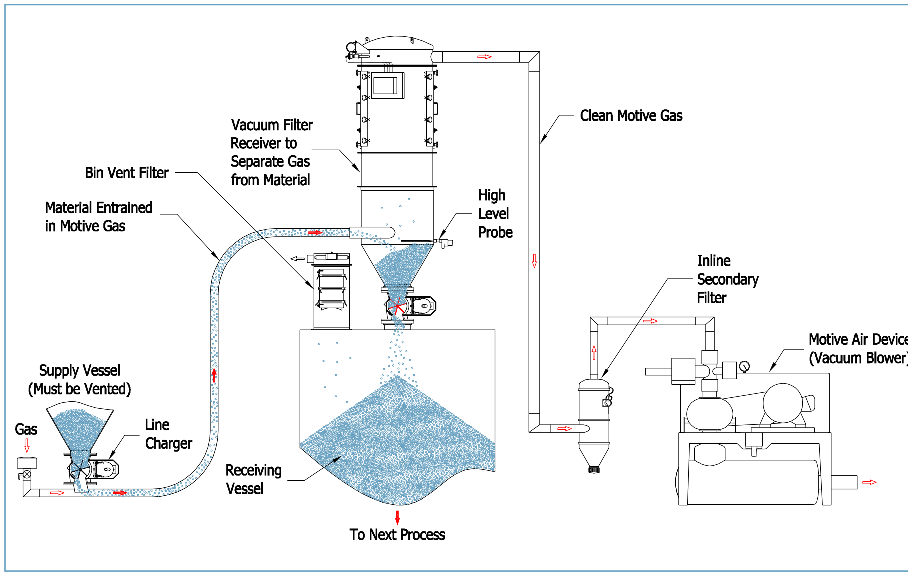

Figure 2 - Typical dilute phase vacuum system

	Pressure System	Vacuum System
Convey Efficiency	• More versatile due to available pressure drop across blower • Equivalent rates may require smaller blower • Size and line sizes, possibly less $$	• Vacuum system has less available pressure drop • Equivalent rates may require larger pump and line sizes , possibly higher $$
Receiving Vessel	• Can be at atmospheric pressure and requires less filter area – generally smaller filter size	• Receiving vessel must be able to withstand vacuum and be reinforced accordingly
Product Temperature	• Temperature rise across blower may heat product, may require inline cooling at added cost	• Temp rise is after product conveyed – no rise in product temperature
Leakage	• Powder leakage risks blowing out of convey line to environment	• Negative pressure prevents powder leaks/escape
System Design	• Ideal for multiple destination, typically requires means to overcome pressure differential at inlet, such as rotary airlock	• Ideal for multiple pick up points, simple pick up designs such as wands or pick up hop pers can be used without airlocks

Table 1 - Comparison of positive pressure vs. vacuum conveying

Dense Phase or Dilute Phase Conveying?

In addition to the choice of positive or negative pressure, conveying systems are also available in a dilute phase or dense phase of operation. By definition, dense phase means a higher product to gas ratio, or a smaller amount of gas used to move a large quantity of product. Graphic illustration of the material to gas ratios in dense and dilute phase systems is shown in Figure 3. In general, the less the gas requirement, the less the power consumed by the exhauster or vacuum blower.

Due to the lower gas velocity used with dense phase conveying, a much gentler action is delivered to the conveyed powder or particle. This gentle action also reduces the segregation issues often experienced with the more aggressive dilute phase operation.

For these reasons, in pet food operations dense phase conveying is often used to convey the pre-blends before going to the extruder, as well as the pet food kibble after the dryer/coating processes. It is important to note that by minimizing any kibble degradation or fines creation, that the system is not only protecting the product integrity, it is also minimizing the generation of additional dusting which can add to possible contamination points in the manufacturing line.

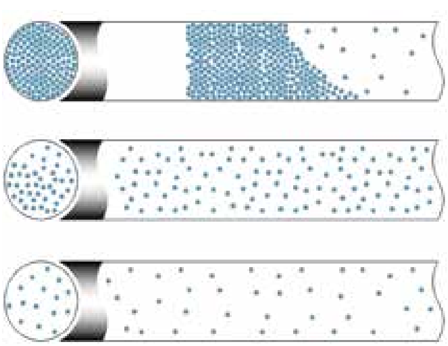
Figure 3 - Examples of material loading dilute vs. dense phase

Dense Phase Vacuum Systems

Dense phase can also be used in vacuum systems, as illustrated in figure 4. This configuration is primarily used when the headroom below the source is limited. It has a limitation on conveying distance of 60 to 90 m [200 to 300 ft] based on the energy that can be produced by a vacuum blower or pump. This method is also very well suited to fragile and/or sticky materials as the material is pulled through the convey line rather than pushed as in a pressure system.

The bulk material moves in the form of compact slugs. The slugs normally form naturally after entering the convey line via the rotary valve feeder or vacuum pickup adapter. The slug length results from the balance between the driving forces (air flow) and the resistance forces (pipe friction, material on material friction). Regular fluctuation of the conveying vacuum is normal in order to achieve stable slug formation. The system operates at high vacuum and low air flow with a high material to air ratio, and conveys at velocities well below the saltation velocity of the material, resulting in lower exit velocity of the material from the convey line into the vacuum filter receiver.

Material is continuously conveyed until the system is stopped manually by the operator or automatically when a high level indication is received from the destination.

If the line becomes plugged and excessive vacuum occurs, a pressure differential switch on the vacuum pump or positive displacement vacuum blower will activate a circuit in the controls that triggers the automatic, orderly shutdown of the system, including opening of the vacuum breaker valve. This protects the system components from excessive differential pressure and damage.

The optional addition of an air control unit ensures the conveying stability of the conveying system, preventing dilute phase operation and unstable (high velocity) slugs while ensuring lowest possible conveying velocity. The air control unit also provides:

- Optimized adjustment for different operating conditions
- Adjustment of the conveying air flow for different pipe diameters
- Adjustment of the conveying air flow due to varying conveying vacuum based on varying convey rate requirements, distances and product grades
- Vacuum related compensation for potential air inlet leakage
- Adjustment of the clean gas airflow

Dense Phase Continuous Rotary Valve Pneumatic Conveying

Dense phase continuous rotary valve systems employ high air pressure (typically above 1.03 bar(g) [15 psi(g)]) and low air volume as the motive force to convey mostly granular bulk solid materials through a pipeline at low velocity. This low velocity makes this type of bulk solid materials conveying especially suitable for friable materials and ideal for products like pet food kibble. Basic operation consists of the high pressure rotary valve being filled from another vessel or device by gravity (Note that the surge vessel DOES NOT need to be a pressure vessel). When the high pressure rotary valve is started, and motive air is supplied to the clean convey line side of the rotary valve line adapter, the material flows into the convey line and to the destination selected. The high pressure rotary valve drastically reduces leakage from the convey line up into the vessel above the high pressure rotary valve. This allows more efficient operation as more motive air is being used to convey material and the minimum amount of air is lost to leakage through the high pressure rotary valve. The motive air source is typically compressed air. This type of system can be adjusted to achieve dilute phase flow, dense phase flow and any phase in between.

Dense phase continuous rotary valve systems can be broken down into two types of configurations:

1. Dense Phase Continuous Rotary Valve Pneumatic Conveying via Natural Slug Formation
2. Dense Phase Continuous Rotary Valve Pneumatic Conveying via Artificial Slug Formation

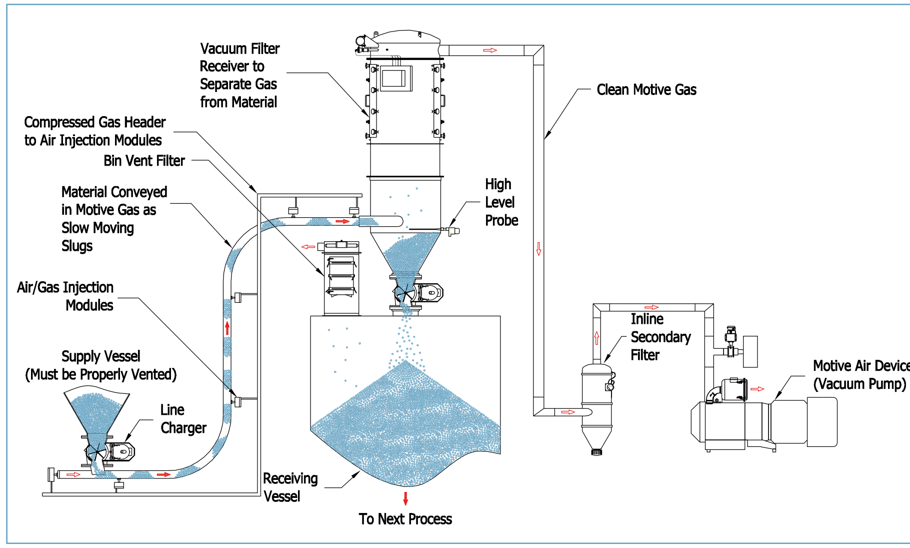

Figure 4 - Typical dense phase vacuum system

Natural Slug Formation

The dense phase continuous high pressure rotary valve (natural slug formation) configuration (Figure 5) is particularly adept at handling pellet and granular materials at high feed rates over long distances without degrading the material. One of the other main advantages is that the surge vessel over the high pressure rotary valve does not need to be pressure rated as it is typically at atmospheric pressure. This is also convenient for applications where there is very little headroom available for equipment installation. The slugs form naturally from a combination of the geometry of the high pressure rotary valve pickup shoe and distance to the first vertical convey line direction change.

The bulk material moves in the form of slugs traveling over a thin bed of the material. Material is constantly exchanged between the bed and the slug as it moves through the convey line. The slugs normally form naturally after entering the convey line via the high pressure rotary valve. The slug length results from the balance between the driving forces (air flow) and the resistance forces (pipe friction, material on material friction). Regular fluctuation of the conveying pressure is normal and is indicative of stable slug formation. The system operates at high pressure and low air flow with a high material to air ratio. Conveying velocities are typically well below the saltation velocity of the material, resulting in lower exit velocity of the material from the convey line.

Material is continuously conveyed until the system is stopped manually by the operator or automatically when a high level indication is received from the destination. After manual or automatic system shutdown is initiated, the following shutdown sequence occurs:

1. The high pressure rotary valve stops

Photo 2 - Dense phase conveying system

feeding material into the conveying line
2. A preprogrammed timed delay allows the conveying line to be purged of material
3. The air compressor package is deactivated or stops supplying air to the system
4. The bin vent or filter receiver at the destination is deactivated.

If the line becomes plugged and excessive pressure occurs, a pressure differential switch on the compressor package will activate a circuit in the controls that triggers the automatic, orderly shutdown of the system. This protects the system components from excessive pressure and damage.

The addition of an air control unit ensures the conveying stability of the conveying system, preventing dilute phase operation and unstable (high velocity) slugs while ensuring lowest possible conveying velocity.

Artificial Slug Formation

The dense phase continuous high pressure rotary valve (artificial slug formation) configuration (Figure 6) is particularly adept at handling pellets, granular materials and highly fluidizable powders at high feed rates over long distances without degrading the material. One of the other main advantages is that the surge vessel over the high pressure rotary valve does not need to be pressure rated as it is typically at atmospheric pressure. This is also convenient for applications where there is very little headroom available for equipment installation. In this configuration the high pressure rotary valve can actually be starve fed from the source.

The bulk material moves in the form of slugs traveling over a thin bed of the material. Material is constantly exchanged between the bed and the slug as it moves through the convey line. The slugs are artificially formed after entering the convey line via the high pressure rotary valve. Continuous material slug conveying is achieved by alternating the supply of primary air source, and intermittent secondary air injection based on a point level indicator in the high pressure rotary valve pickup adapter or a timer. The slug length is regulated by the secondary air, each injection of secondary air marking the formation of a slug of material. The secondary air utilizes the same air source as the primary conveying air. The system operates at high pressure and low air flow with a high material to air ratio, and conveys at velocities well below the saltation velocity of the material, resulting in lower exit velocity of the material from the convey line.

Material is continuously conveyed until the system is stopped manually by the operator or automatically when a high level indication is received from the destination.

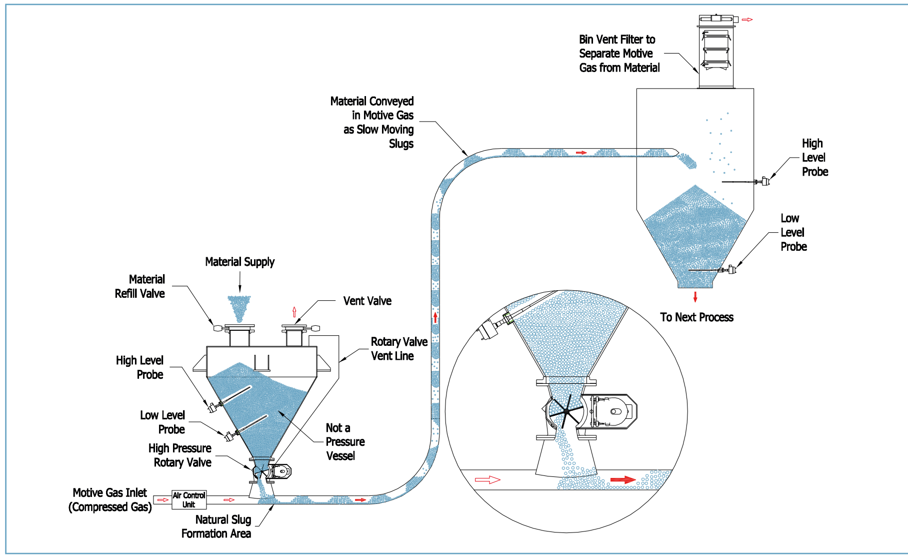

Figure 5 - Natural slug formation

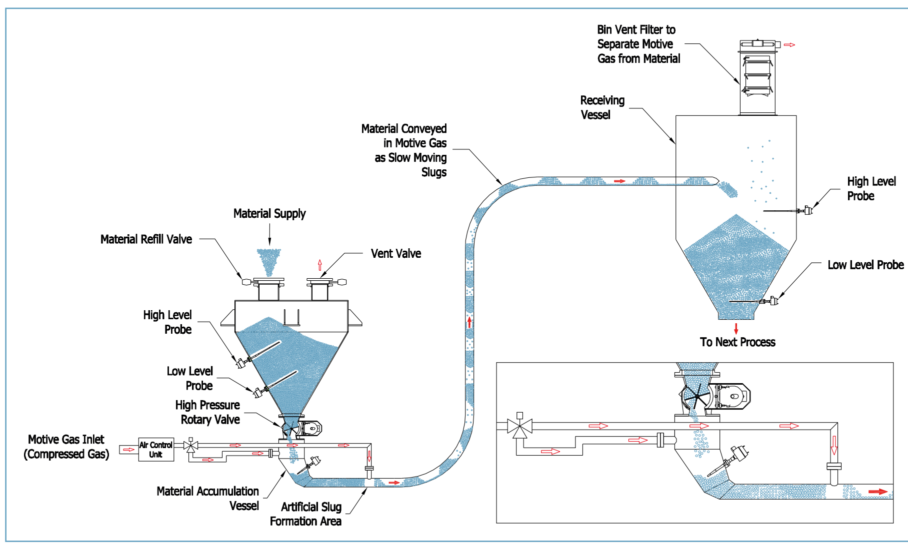

Figure 6 - Artificial slug formation

If the line becomes plugged and excessive pressure occurs, a pressure differential switch on the compressed air package will activate a circuit in the controls that triggers the automatic, orderly shutdown of the system. This protects the system components from excessive pressure and damage.

The addition of an air control unit ensures the conveying stability of the conveying system, preventing dilute phase operation and unstable (high velocity) slugs while ensuring lowest possible conveying velocity.

Options for Cleaning and Improved Food Safety in Pet Food Convey Systems

Food safety and contamination avoidance is of utmost importance when handling any food product. Due to a variety of options available in safe and efficient process equipment design, it is very important that the equipment manufacturer be experienced in a variety of engineering design regulations and standards, such as EHEDG, FSMA, GFSI, USDA, 3A, etc. Today's pet food manufacturers require equipment partners who can not only educate them in the options available to meet these standards, but also ensure a cost effective process solution.

It is important to note that for ease in cleaning and product changeover, pet food conveying designs are available for all of the conveying methods outlined above to ensure minimal downtime and to ensure the system is completely cleaned and safe. Equipment manufacturers which can provide these key insights into their designs are quickly becoming the equipment partners of choice. In addition, design innovations are also available for all the pneumatic conveying and handling systems prior to and after the extruder.

For example, one such design involves unique, easy access of cleanable rotary and diverter valves for use throughout the pneumatic conveying process. These valves can incorporate a number of design features including complete access of both the rotor and drive ends, as shown in photo 4.

In addition, the recently introduced Coperion K-Tron Sanitary Filter Receiver (SFR) (photo 3) has been completely designed and engineered based upon in-depth discussions with pneumatic conveying receiver users in the pet food and food industries. The unique top entry and special custom engineered side access filter assembly of the SFR allows for high efficiencies, with minimal degradation of the product due to decreased can velocities, and extremely high access to all internal areas of the receiver for cleaning. In addition, the availability of oleophobic filter material for this type of filter can be especially important when dealing with high fat content kibble materials.

Photo 3 - Sanitary filter receiver

The reduction in time alone for complete filter change out and cleaning compared to typical side tangential inlet, top removal cartridge or bag filter designs can be significant to overall process and product changeover times. It is important that the equipment manufacturer discuss in detail with the end user the methods of cleaning that will be used for the process, for example either wet or dry, and make design recommendations to accommodate the cleaning process, such as retractable spray balls for CIP/WIP systems, or minimal horizontal ledges which can be easily wiped clean for dry cleaning. By including upfront design features which focus on accessibility and ease of cleaning, pet food process times can ensure product safety as well as quick changeover times.

In addition to cleanability of the pneumatic conveying system, it is also important to evaluate any dust control or explosivity concerns, particularly in dealing with palatants (flavor enhancers) added to the dried kibble. Whole kibbles are generally benign and easy to handle, however, considerations must be made when handling palatants. It is crucial that dry palatant material handling, application design and recovery devices have adequate dust control to minimize dust creation as some palatants can be an irritant or possess characteristics of an explosive dust.

Photo 4 - Hygienic rotary valve with quick extraction system

Summary

As outlined above, a variety of pet food conveying methods are available complete with options in design and configuration to ensure minimal degradation of the product as well as optimized efficiency. It is important to evaluate your complete system and material requirements with your conveying system supplier to ensure that the most cost effective, efficient and most importantly, safe design is provided.

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