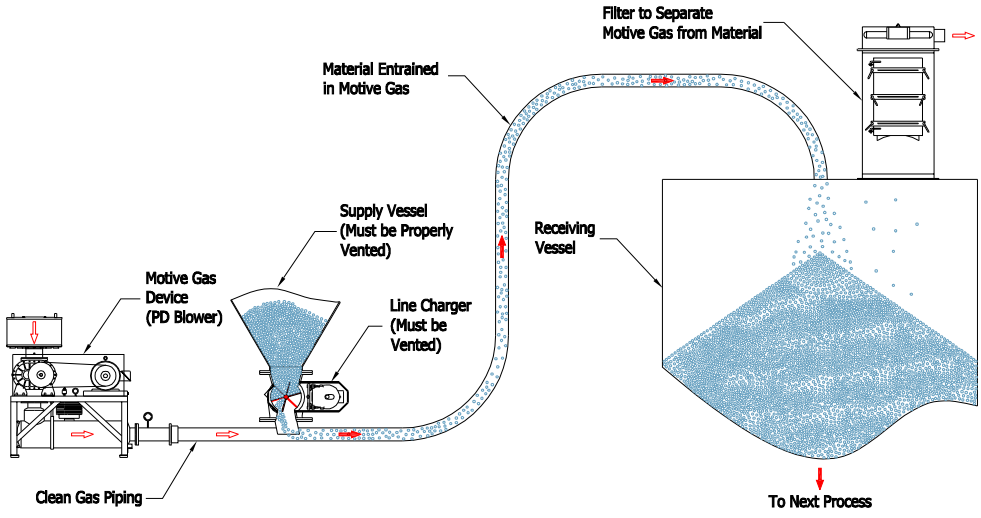
Dense Phase Conveying: Efficient Transfer **for a Wide Variety of Food Ingredients**

Today's processed 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 minor), ingredient blends prior to their next process step or final product prior to packaging. By properly selecting the best method for the application, a much more cost effective and reliable means of material handling can be achieved. This article will outline and define the methods of pneumatic conveying available for a variety of unit operations in food processing.

Pneumatic transfer – vacuum or pressure?

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. 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, as 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. 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 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 rotary airlock valves, 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.

Figure 1: Typical dilute phase positive pressure system



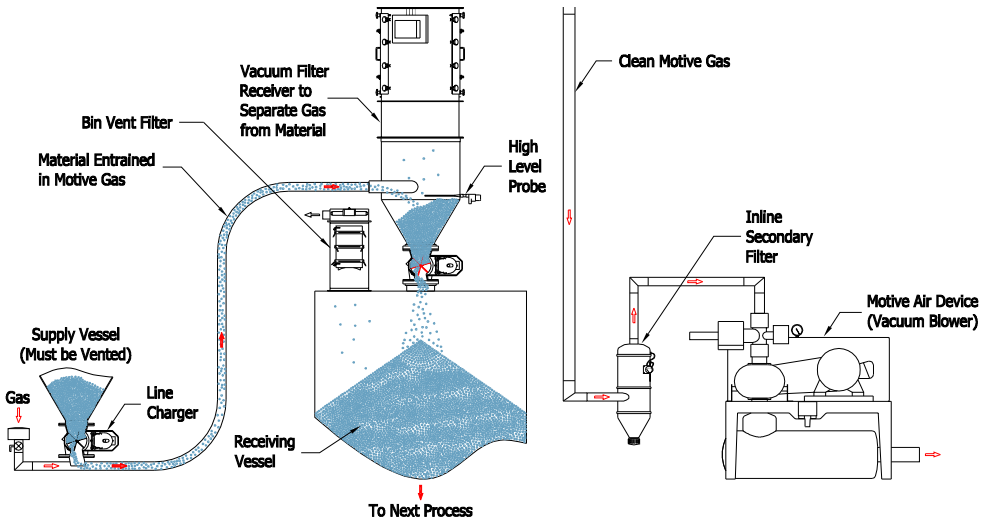
"Positive pressure conveying systems are typically used to transport product over long distances"

Dense phase or dilute phase conveying?

In addition to the choice of positive or negative pressure, conveying systems are also available in a dilute or dense phase of operation. By definition, dense phase systems convey material below or significantly below the product saltation velocity. This low velocity conveying means a higher product to gas ratio, or a smaller amount of gas used to move the same or larger quantity of product. In general, the less gas required, the less power consumed by the pneumatic conveying system.

Due to the lower gas velocity produced with dense phase conveying, a much slower, gentler conveying action is imparted to the material. This gentle action also reduces the segregation and attrition issues often experienced with the more aggressive dilute phase operation. For these reasons, in food operations dense phase conveying is often used to convey the pre-blends before going to the next process step, as well as the final products going to packaging.

Figure 2: Typical dense phase vacuum system



Dense phase vacuum systems

Dense phase can be used in vacuum systems, as illustrated in Figure 2. Dense phase vacuum has a limitation on conveying distance of 60 to 90 m 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 form naturally after entering the convey line via the rotary valve feeder or vacuum pickup adapter. 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. The advantages of using dense phase vacuum systems include the ability to contain food ingredients more efficiently within the line, due to the vacuum which is pulling inward to the system. In addition, its simple and easy-to-clean design makes it an excellent choice for simple up and in applications.

Dense phase positive pressure

Dense phase pressure systems are used to convey food ingredients for a wide range of applications due to their ability to convey efficiently at long distances and high capacities. Utilizing positive pressure dense phase is especially appropriate when handling products which are friable or fragile, have a tendency to segregate, or are temperature or moisture sensitive. They are particularly favored over vacuum dense phase systems when the distance to be conveyed is long (usually in excess of 91.44 m). It should also be noted that due to innovations available in the sanitary and hygienic design of the components of a dense phase system, such as the Coperion K-Tron sanitary filter receiver, easy clean and disassembly options are available, making them perfect for food applications. Typical dense phase positive pressure systems as utilized in the food industry can be broken down into dense phase pressure vessel systems and dense phase rotary valve pressure systems.

“Dense phase vacuum has a limitation on conveying distance of 60 to 90 m”

Dense phase pressure vessel systems

Dense phase pressure vessel systems employ high air pressure through a pipeline at low velocity. This low velocity makes this type of bulk solid materials conveying especially suitable for abrasive, friable or premixed food blends. Basic operation consists of the pressure vessel being filled from another vessel or device by gravity. When the pressure vessel is full, the inlet and vent valves close, the convey system is pressurized, and the material flows into the convey line to the destination selected. In most cases the convey line is equipped with supplementary air (or bypass air) injectors to aid in material flow and minimize material velocity in the convey line. Air injection points will break down the convey distance into several smaller distances thereby reducing the resistance and pressure necessary to move the material through the convey line. The resulting slug flow reduces the area of material in contact with the convey line inner diameter, and therefore reduces friction. The reduction in friction in turn results in less abrasion, reduced degradation and reduced segregation.

Dense phase continuous rotary valve systems

As an alternative to the pressure vessel dense phase systems, dense phase continuous rotary valve systems employ high air pressure and low air volume. This low velocity makes this type of bulk solid materials conveying especially suitable for friable materials and ideal for larger particle size products like rice, coffee beans and ingredients like hops used in beer production.

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. Dense phase continuous rotary valve systems can include designs utilizing natural and artificial slug formation.

Coperion K-Tron Sanitary Filter Receiver

Food Safety

Food safety and contamination avoidance are 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 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, 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. An example of a pneumatic system design innovation includes 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. 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.

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Summary

As outlined above, a variety of 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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يبحث اليوم مصنعي المواد الغذائية المجهَّزة باستمرار عن طرق لتحسين كفاءة عملية التصنيع، عدد مرات الإنتقال، وبطبيعة الحال ضمان سلامة المنتج. واحدة من التقنيات الأساسية التي يمكنها أن تساعد في معالجة كل هذه العوامل وتحسينها هو الناقل الهوائي، بصرف النظر عما إذا استُخدم في نقل المكونات الخام (الرئيسة والثانوية)، خليط المكون قبل استخدامه في العملية التالية أو المنتج النهائي قبل التوضيب. وعند اختيار الطريقة المثلى لنوع الاستخدام، يمكن تحقيق وسائل فعالة وموثوق بها بدرجة كبيرة في مجال معدات مناولة المواد. سيسلط هذا المقال الضوء على طرق الناقل الهوائي المتوفرة لمجموعة متنوعة من وحدة العمليات في مجال تجهيز الأغذية. وتشمل مرافق التصنيع الغذائي عادة عدة أنواع من أنظمة الناقل الهوائي. ويعتمد أسلوب نقل المكونات الخام أو حتى المنتج النهائي على عدَّة مقاييس خاصة بالعملية ومنها: خصائص المواد، مسافة النقل، معدل النقل المطلوب، هشاشة المنتج أو مخاوف الفصل. ولذلك فمن المهم عند اختيار طريقة النقل أن يتم القيام بفحص شامل لعدد من مقاييس العملية، بما أنَّه يمكن لخيارات مختلفة أن تؤدِّي إلى التوفير من حيث التكلفة وتحسين الكفاءة. إنَّ سلامة الغذاء وتفادي تلوثه لهما أهمية قصوى في عملية معالجة أي منتج غذائي. وتتوفَّر مجموعة متنوعة من الخيارات في تصميم معدات آمنة وفعالة للعملية، لذا من المهم جدا أن يكون لدى مصنِّع المعدات الخبرة في مجموعة متنوعة من أنظمة ومعايير التصميم الهندسي. ومن المهم تقييم النظام الكامل والمتطلبات المادية في كل مصنع مع مزود نظام النقل الخاص، لضمان تأمين التصميم الأكثر فعالية من حيث التكلفة والكفاءة والأمان.