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Ask Joe! Column

You Too, Can Select a Pneumatic Conveying System

Guest article by Tim Singer, Pneu Solutions

Pneumatic conveying is the most practical method for moving large amounts of dry powdered, granulated, and pelletized materials. Pneumatic conveying refers to the movement of these materials by either suspension or force through a gas stream in horizontal and/or vertical pipes. The process of selecting a properly designed system can sometimes be difficult. This article is intended to give the reader some general information about the optional conveying methods that are available and how to determine which methods are suitable for the thousands of different materials being pneumatically conveyed today.

Conveying Methods - Phases

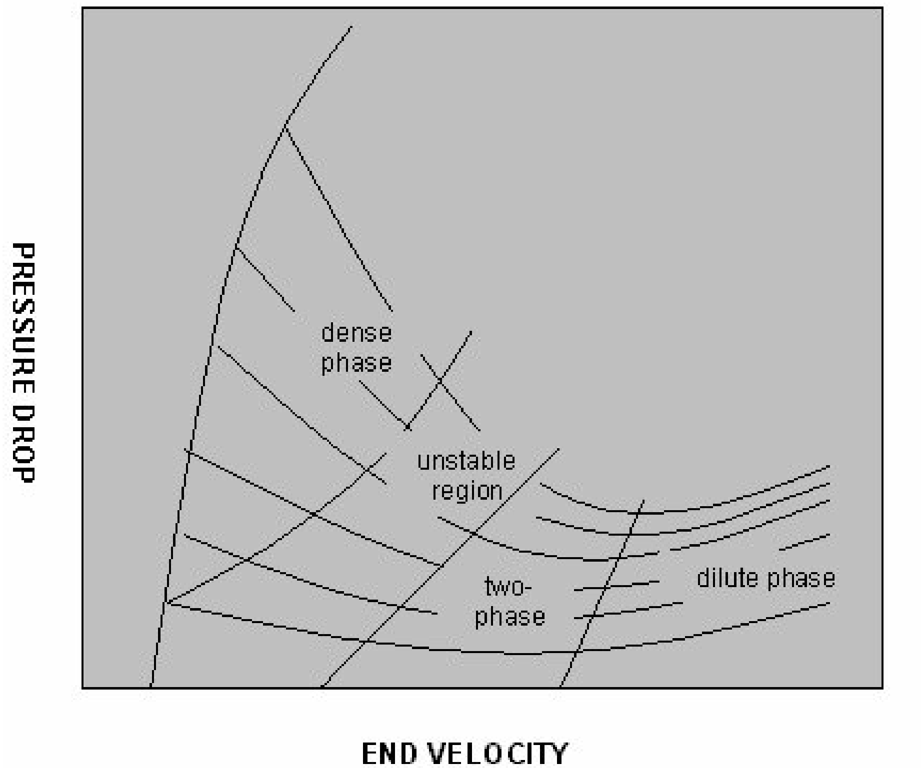
The general categories of pneumatic conveying, also referred to as “phases” are as follows:

1. Dilute phase operation (pressure, vacuum, or combination of both)
2. Two-phase operation (primarily pressure)
3. Dense phase operation (pressure or vacuum)

The primary difference between the “phases” is the difference in the velocity at which the material is moved through the pipeline. Dilute phase systems operate with high product velocities such that all of the particles are separated from each other and suspended in the gas stream. Dense phase systems operate with product velocities below the “saltation” velocity (saltation velocity is the critical velocity where particles fall from suspension in the pipe). The compressed gas source then pushes the material down the pipeline. The material will form dunes and/or solid pistons that are separated by pockets of gas as the material moves through the line. Two-phase operation is just what the name describes. It is an operating state which is primarily designed below the “saltation velocity of the material, as in lower velocity dense phase systems, but at pipeline velocities which border on the higher dilute phase velocities as the product approaches the end of the convey line.

More pneumatic conveying suppliers are differentiating this particular design and using this terminology more as they perform conveying tests on different materials and purposely design systems to operate in this velocity region. Figure 1 shows a typical phase diagram for pneumatic conveying systems that illustrates the states more clearly. With most materials, there is a region between dilute phase and dense phase where systems will operate unstable. In this region, the pressure fluctuations are dramatic. When these pressure swings are trended over time, they can be viewed graphically as sinusoidal waves.

Figure 1: Phase Diagram for Pneumatic Conveying Systems



In order to determine the correct conveying method, the right questions must be asked. Which conveying methods will support the material being transported? What is the purpose of the material transfer system? Is it simply to move the material from point A to point B? Is it to move more material from point A to point B? Is it to move material from point A to point B more reliably? How about to move it more efficiently, or more gently? The answers to these questions are part of the selection process to determine the best conveying method.

Dilute phase conveying is still the most cost effective, simple, and versatile design to use. It is the most widely used technology and the most understood. The two-phase conveying operation can save on total system energy requirements, but is used on a fairly limited basis. The material must fall into a specific area of physical properties for this type of operation to perform properly. Two-phase conveying is not a good selection if the material properties are subject to variation over time. Dense phase systems typically carry a higher price tag, but have advantages over dilute phase designs when product degradation or pipe erosion is the major concern.

Vacuum dilute and vacuum dense designs can almost be separate entries because they each have unique qualities and applications of their own. Vacuum dilute systems can simplify a total equipment package. Vacuum dilute systems are commonly used where space limitations for equipment exist, such as railcar or truck unloading. Vacuum dense systems can be used where very low product degradation is desired. It can be used when the material properties are somewhat sticky or cohesive. Since vacuum systems will pull the material rather than push it, vacuum systems can be used on materials that may tend to pack and plug in a pressure system.

All dry bulk solid materials will work in dilute phase. Some materials will work in dense phase. Very few materials are candidates for two-phase conveying. Before a decision can be made as to which conveying method will work, the material must be physically analyzed and classified.

Bulk Materials Categories

Materials fall into one of the three general categories of dry bulk materials:

1. Free-flowing (usually granular or pelletized)
2. Sluggish (free-flowing when fluidized)
3. Non-free-flowing (cohesive, stringy, or platelet).

The term “fluidizable” or “fluidization” of a material refers to the ability of a material to take on the characteristics of a liquid when a small quantity of a gas is entrained within it. Each individual particle is separate and suspended by the gas, hence inter-particle friction is reduced considerably. In this fluidized state, the material can be moved easily through the pipeline at low velocities and low energy consumption rates. Some materials retain the fluidized gas longer than others. This term is known as air retention time. The longer the air retention time, the easier the material will convey in dense phase or two-phase.

The physical and mechanical properties of every material are broken down in greater detail and classified for suitability for the possible modes of transfer. There are many different product grades within the same product group. It is not correct to say that fly ash will convey well in dense phase mode. In fact, most grades do not. Only post-precipitator fly ash will convey easily in dense phase. A thorough analysis of the mechanical properties of every material is a normal procedure for most pneumatic conveying specialists. Some pneumatic conveying equipment suppliers will not guarantee system performance unless they receive a sample of the material being conveyed.

Coarse, Sluggish and Non-Free Flowing Materials

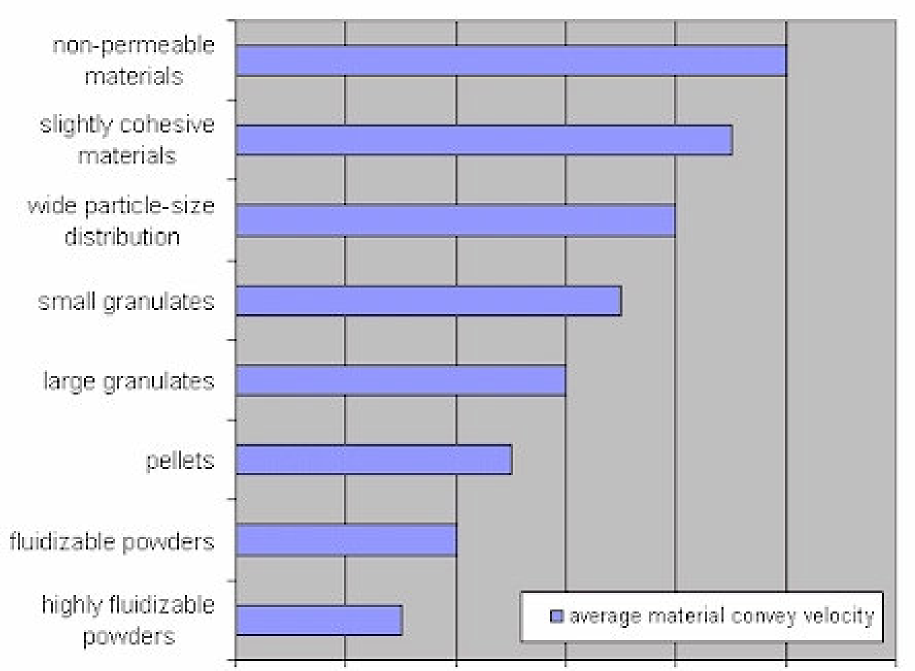
A coarse material like plastic pellets is the ideal example of a material in the free-flowing material group. They are good dense phase candidates. This material group has a uniform particle size, is non-cohesive and non-compressible. Pellets are permeable and allow air to pass through the material pistons. The ability of a material to be permeable in a piston form will help prevent convey line blockages, which is a common problem of dense phase systems.

The second general category is the sluggish materials group. The more sluggish the flow of the material, the less of a candidate it is for dense phase or two-phase conveying. Materials such as granulated sugar, sand, or crushed lime are not permeable, but they can still be conveyed reliably below the saltation velocity. These materials will not convey at very low velocity in uniform piston form, as the pellets, but will still convey at increased velocities. The convey line velocities must be increased to reduce piston lengths and prevent line blockages.

Many materials are not appropriate candidates for dense phase transfer. These materials fall into the non-free-flowing category. Sticky, cohesive, adhesive, or non-fluidizable materials will not be suitable candidates for dense phase transfer. Very fine powders (less than 300 mesh) are also difficult to convey. They will tend to pack in the convey line.

Figure 2, below, shows a basic relationship between different material groups and their ability to be conveyed at low velocities. The velocities represented are all operated with pick-up velocities below the saltation velocity. The material groups are illustrated only as a first approach. Some groups may actually overlap into higher or lower velocity requirements depending on their individual mechanical and physical properties.

Figure 2: Dense Phase Conveying Materials Groups



It is desirable for the system designer to know what the lowest possible pick-up velocity is for a specific material and which modes of transfer will support a reliable operation. It is also necessary to know what the total convey line pressure drop is with good accuracy. The total required gas volume is very much dependent on the total system pressure drop. A significant underestimation of pressure drop can leave the system with an insufficient supply pressure, volume, or both. If this occurs, the usual consequence is that the material transfer rate must be reduced. If the total system convey pressure is highly over-estimated, the system will be over-designed and will waste energy.

About our author

Tim Singer is currently an independent pneumatic conveying consultant and holds a BSME from the University of Illinois in Chicago. Since 1987, he has held various technical positions with leading suppliers of pneumatic conveying systems. If you have any questions about this article, please contact the author at:

Pneu Solutions
16823 Cimarron Drive
Magnolia, TX 77355;
Telephone: 281-252-8850
http://www.pneusolutions.com/

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Welcome to Ask Joe!, a monthly column by our resident materials handling guru, Joe Marinelli of Solids Handling Technologies. Joe addresses the issues that bug you the most. And Joe knows!! Formerly with Jenike & Johanson, Solids Flow and Peabody TecTank, Joe is an expert on materials handling.

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