

PNEUMATIC CONVEYING

INTRODUCTION

A well designed pneumatic conveying system is often a more practical and economical method of transporting materials from one point to another than alternative manual or mechanical systems. This Engineering Letter outlines some of the fundamental principals of pneumatic conveying systems and explains various special considerations for fan selection.

TYPES OF PNEUMATIC CONVEYING

Pneumatic conveying encompasses numerous different system designs, technologies, and pressure ranges; however, there are only three basic methods for moving material with air. These can be categorized into the following system types:

Dilute-phase conveying is the process of pushing or pulling air-suspended materials from one location to another by maintaining a sufficient airstream velocity to capture and convey the suspended particles.

Dense-phase conveying relies on a pulse of air to force a slug of material from one location to another. This form of conveying usually requires positive displacement blowers or compressors to generate the necessary pressure of 1.5 to 30 psig or more.

Air-film or air-float conveying is a means of moving product along a conveyor on a cushion of air.

The use of fans for pneumatic conveying is generally limited to dilute phase conveying and air film conveying.

DILUTE-PHASE CONVEYING

In this method of conveying, material is suspended in the airstream. Suction or vacuum are not factors in this type of system and fan static pressures are no greater than 60" WG. If the system uses a fan on the exhaust end and the material is collected or separated from the airstream before it reaches the fan, the fan itself can be of a more efficient type such as backwardly inclined. If the system is designed so that the combined material and air mixture passes through the fan, selection is limited to the more rugged but less efficient fan types intended for material laden airstreams. A number of radial-blade wheel designs are available to handle various concentrations, sizes, and types of airborne particles. Radial-tip wheel designs are tolerant of airborne contaminants, but radial-tip fans are not generally thought of as bulk material handling designs. In all cases, the fan manufacturer should be consulted to determine the most appropriate fan type available to handle the specific material quantity and type, but it must be understood that the fan manufacturer can neither control the variables in pneumatic conveying systems nor provide any guarantee of the service life of the fan itself.

Applications requiring fans for dilute-phase pneumatic conveying fall into one of three basic categories: dust collection, fume removal, or material conveying.

DUST COLLECTION AND FUME REMOVAL

Dust collection, fume removal, and material conveying systems each have unique characteristics, but all three are similar in their dependence upon proper air velocities.

Dust collection and fume removal are generally thought of as "housekeeping" systems that usually incorporate a hood at the system entry point. There are many types and styles of hoods in common use, and hood design is a subject in itself. Some state and local codes offer hood design criteria, and there are several reference texts, such as Industrial Ventilation - A Manual Of Recommended Practices, that can assist in the selection and design of hoods. In all cases the hood design should minimize turbulence and offer the lowest possible entrance losses.

Determining the minimum velocity for dust collection or fume removal is often a matter of practical trial-and-error judgment. State and local codes may dictate minimum velocities for certain materials. Where no codes apply, the velocities shown in Figure 1 can be used as conservative estimates. Since these velocities are conservative, it is often possible to reduce them through experimentation. Reducing the velocity to near the settling point will generate the lowest overall operating cost but raises the risk of system plugging, increased maintenance costs, and lost production.

Dust Collecting and Fume Removal Duct Velocities

Material	Velocity in FPM	Material	Velocity in FPM
1. Grinding Dust	5000	20. Jute Dust	3500
2. Foundry Dust	4500	21. Grain Dust	3000
3. Sand Blast Dust	4000	22. Shoe Dust	4000
4. Wood Flour	2000	23. Rubber Dust	3500
5. Sander Dust	2000	24. Rubber Buffings	4500
6. Shavings, Dry	3000	25. Bakelite Moulding Powder	3500
7. Shavings, Wet	4000	26. Bakelite Moulding Dust	2500
8. Sawdust, Dry	3000	27. Oven Hood	2000
9. Sawdust, Wet	4000	28. Tail Pipe Exhaust	3000
10. Wood Blocks	4500	29. Melting Pot and Furnace	2000
11. Hog Waste	4500	30. Metallizing Booth	3500
12. Buffing Lint, Dry	3000	31. Soldering Fumes	2000
13. Buffing Lint, Wet	4000	32. Paint Spray	2000
14. Metal Turnings	5000	33. Carbon Black	3500
15. Lead Dust	5000	34. Paper	3500
16. Cotton	3000		
17. Cotton Lint	2000		
18. Wool	4000		
19. Jute Lint	3000		

Figure 1

MATERIAL CONVEYING

Although the differences between dilute-phase material conveying systems and dust collection or fume removal systems might appear to be minimal, there are certain distinctions that are critical to the successful operation of material-conveying systems. These differences include the method of introducing the material to the hood, the velocity requirements, the duct configuration, and the fan type.

The introduction of material into a material conveying system can be difficult. The most important criterion is to feed the material into the airstream evenly. This can be accomplished by means of gravity or by a mechanical device.

A hood or hopper can be used as a gravity feeder. Use of these components is limited to dry, free-flowing materials. It is important to remember that it is the velocity moving around and past the material that induces it to flow. If the entry becomes plugged with material, the required velocity cannot be maintained, significantly impeding air and material flow.

A venturi feeder can be used to introduce material into the airstream. Like the hood, it has no moving parts so there is virtually no maintenance. However, the design of the venturi must be tailored to each application and even the best ones can be rather easily blocked if system conditions vary. Typical throat velocities are 2 to 3 times the velocity in the main duct...see Figure 2.

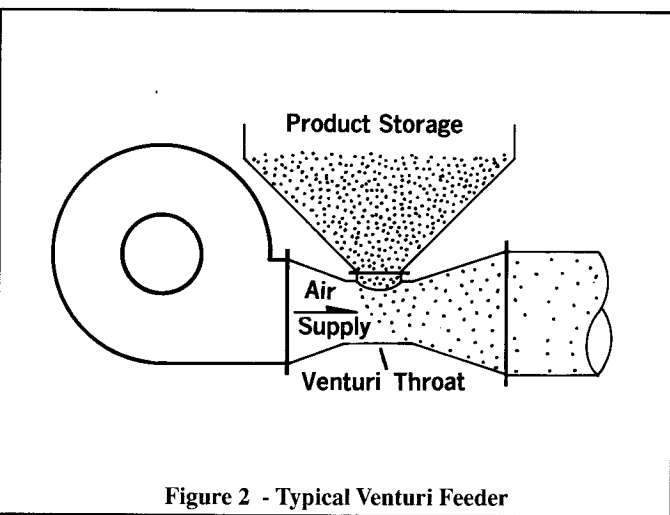


Figure 2 - Typical Venturi Feeder

Rotary valves and screw-type (auger) feeders (see Figure 3) are the most common mechanical devices used to introduce material into the airstream. Both types offer a controllable flow rate and are readily available in a number of standard designs to handle pressures common to dilute phase conveying. However, there are some precautions. Both are typically more expensive than gravity-feed alternatives. Rotary valves can experience internal air recirculation which causes a reduction in material through-put. The screw-type feeder is a relatively high maintenance device. In either case, the manufacturer of the specific feeder should be consulted for selection, equipment recommendations, and system limitations.

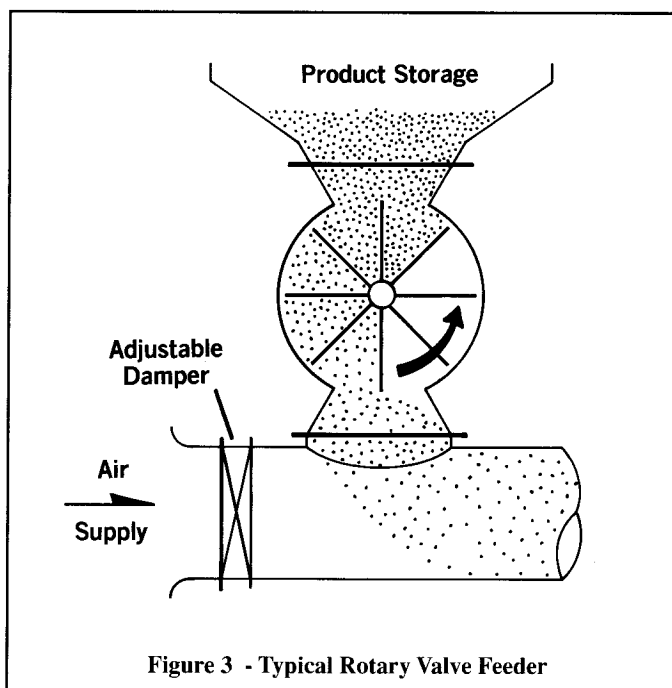


Figure 3 - Typical Rotary Valve Feeder

Since the purpose of a conveying system is to move quantities of material suspended in air, the ratio of material to air (by weight) is critical. The most common form of reference is to state the ratio according to the combined weight in pounds per hour. A conservative design approach is to keep the ratio of matter-to-air below a 1:2 proportion. However, successful systems have been designed using material loadings of 1:1 or more when the system components are well-designed and eliminate sharp turns, abrupt junctions, or other potential points of binding, clogging, or drop-out and the material being conveyed is well-defined and consistent.

Certain minimum conveying velocities must be maintained to keep the material in suspension and flowing. To some extent these velocities are dictated by, or at least related to, the material-to-air ratio. For example, conveying sawdust at a rate of 1800 lbs./hr. through a 6" pipe with a material loading ratio of 1:2 will result in an air velocity of 4073 FPM.

$$1800 \text{ lbs./hr. material} = 30 \text{ lbs./min.}$$

$$60 \text{ lbs./min. air} \div .075 \text{ lbs./ft.}^3 \text{ std. density} = 800 \text{ CFM.}$$

$$6" \text{ pipe} = .1964 \text{ ft.}^2 \text{ area inside.}$$

$$800 \text{ CFM} \div .1964 \text{ ft.}^2 = 4073 \text{ FPM.}$$

Figure 4 provides conservative minimum conveying velocities to be used for some common materials. The velocity shown for sawdust is 4000 FPM. If the same 1800 lbs./hr. of sawdust had been introduced to a system with a 1:1 design ratio and there were no other changes to the system, the resulting velocity would only be half and the material would probably settle and clog. To compensate for the lower ratio, the pipe size could be reduced to 4", but this might introduce new problems in feeding the material to the pipe or transitioning to the fan. In this example, the 1:2 ratio would seem to be ideal.

