2 Feeding Devices

1 INTRODUCTION

All pneumatic conveying systems, whether they are of the positive or negative pressure type, conveying continuously or in a batch-wise mode, can be considered to consist of the basic elements depicted in Figure 2.1.

Figure 2.1 Basic elements of a pneumatic conveying system.
Numerous devices have been developed to feed materials into pipelines. In vacuum systems the material feed is invariably at atmospheric pressure and so the pipeline can either be fed directly from a supply hopper or by means of suction nozzles from a storage vessel or stockpile.

1.1 Air Leakage

In positive pressure systems, separation devices invariably operate at atmospheric pressure. Pipeline feeding in positive pressure systems represents a particular problem, however, for if the material is contained in a storage hopper at atmospheric pressure, so that it is continuously available for filling, the material has to be fed against a pressure gradient.

As a consequence of this there may be a loss of conveying air. In certain cases this air flow can interfere with the feeding process. Also, if the loss is significant, the air supply will have to be increased, for the correct air flow rate to the pipeline must be maintained for conveying the material.

1.2 Pressure Drop

Material flow rate through a pipeline is primarily dependent upon the pressure drop available across the pipeline. A basic requirement of any feeding system, therefore, is that the pressure drop across the feeding device should be as low as possible in low pressure systems, and as small a proportion of the total as possible in high pressure systems.

If the feeder requires an unnecessarily high proportion of the total pressure drop from the air source, less pressure will be available for conveying the material through the pipeline, and so the material flow rate will have to be reduced to compensate. Alternatively, if a higher air supply pressure is employed to compensate, more energy will be required, and hence the operating cost will be greater.

1.3 Maintenance

Maintenance is another important factor. Very often air leakage has to be accepted with a particular feeding system, but it is essential that the rate of loss should not increase unduly with time as a result of gradually increasing wear. If undue wear does occur, insufficient air may ultimately be supplied to the pipeline and a blockage is likely to occur as a consequence. This usually happens just after the guarantee has expired!

1.4 Material Properties

Material properties are particularly important and have to be taken into account in the selection of feeding devices. In feeding systems that have moving parts, care has to be taken with both abrasive and friable materials. Material flow properties also need to be taken into account with feeding devices, and particle size must be
considered in all cases, particularly the two extremes of large particles and pellets, and very fine particles and powders.

1.5 Devices Available

Many diverse devices have been developed for feeding pipelines. Some are specifically appropriate to a single type of system, such as suction nozzles for vacuum systems. Others, such as rotary valves, screws and gate valves, can be used for vacuum and positive pressure systems. The approximate operating pressure ranges for various pipeline feeding devices are given in Figure 2.2.

Developments have been carried out on most types of feeding device to increase the operating pressure range of the device and the range of materials capable of being fed. Each type of feeding device, therefore, can generally be used with a number of different types of conveying system, and there are usually many alternative arrangements of the feeding device itself.

1.5.1 Blow Tanks

For high pressure systems, and particularly where the material has to be fed into a system that is maintained at a high pressure itself, blow tanks are commonly employed. These are generally used for conveying batches, although they can quite easily be adapted for continuous conveying. This, of course, is the particular advantage of all the other systems included in Figure 2.2.

The time averaged mean flow rate for a batch type system is somewhat lower than that of the equivalent continuous conveying system. There are, however, numerous ways by which the operating performance of blow tanks can be improved. Because they have no moving parts, blow tanks are often used in low pressure applications. Since there are so many different types of blow tank arrangement, and because they are increasing in popularity, a large section of this chapter is devoted to this type of feeder.

<table>
<thead>
<tr>
<th>Feeding Device</th>
<th>System Pressure - (1\text{bf/in}^2) (gauge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blow Tank</td>
<td>![High pressure]</td>
</tr>
<tr>
<td>Venturi</td>
<td>![High pressure]</td>
</tr>
<tr>
<td>Screw</td>
<td>![High pressure]</td>
</tr>
<tr>
<td>Rotary Valve</td>
<td>![High pressure]</td>
</tr>
<tr>
<td>Gate Valves</td>
<td>![High pressure]</td>
</tr>
<tr>
<td>Suction Nozzle</td>
<td>![High pressure]</td>
</tr>
<tr>
<td>Trickle Valve</td>
<td>![High pressure]</td>
</tr>
</tbody>
</table>

Figure 2.2 Approximate operating pressure ranges for various feeding devices.
7.5.2 Vacuum Conveying

It will be noted that there is no scale on Figure 2.2 for feeding devices for negative pressure conveying systems. This is because in a vacuum conveying system material is normally fed into the pipeline at atmospheric pressure. Only if the inlet to the feeding device was choked would there be a negative pressure. Choking is often employed to help promote the flow of material into the pipeline but the order of magnitude is generally very low.

1.6 Feeding Requirements

The air mover can be positioned at either end of the system shown in Figure 2.1. If the air is blown into the pipeline, the air at the feed point will be at a pressure close to that of the air supply. In this case the material has to be fed into the pipeline at pressure, and so consideration has to be given to the possibility of air leakage across the material feeding device.

If the air mover is positioned downstream of the system, so that it acts as an exhauster to the separator/discharge hopper, the air at the material feed point will be close to atmospheric pressure. In this case the effect of a pressure gradient on the feeding device need not be taken into account. Consideration, however, will have to be given to the possibility of air ingress into the system.

1.6.1 Material Surges

A further requirement of the feeding device is that it should feed the material into the conveying line at as uniform a rate as possible. This is particularly so in the case of dilute phase systems, for the material is conveyed in suspension and quite high values of minimum conveying air velocity have to be maintained. With a mean conveying air velocity of 4000 ft/min, for example, it will only take about six seconds for the air to pass through a 400 ft long pipeline.

If there are any surges in material feed, the pipeline could be blocked very quickly. Alternatively, if the air mover has a pressure rating to make allowance for such surges, the output from the system could be increased if the flow rate, and hence the conveying line pressure drop, was kept constant at a higher value to match the rating more closely.

1.6.2 Flow Metering

Positive displacement feeding devices, such as screws and rotary valves, can serve the dual purpose of both metering the material into the pipeline, whilst effecting the air-lock that is necessary for successful operation, in the case of positive pressure systems.

Some feeders act only as air locks and so require additional equipment to meter the material into the conveying line. Some feeders have no moving parts, and so particular attention is given to them, as their means of material flow control may not be obvious.

Copyright © 2004 by Marcel Dekker, Inc. All Rights Reserved.
2 ROTARY VALVES

The rotary valve is probably the most commonly used device in general industry for feeding materials into pipelines. This type of feeder consists of a bladed rotor working in a fixed housing. In many applications in which it is used its primary function is as an air lock, and so it is often referred to as a rotary air lock. This basic type of valve is generally suitable for free flowing materials. It is a positive displacement device and so material flow rate can readily be achieved by means of varying the speed of the rotor.

The traditional, or low pressure, rotary valve has an upper pressure limit of about 15 lbf/in$^2$ gauge, which closely matches the delivery pressure capability of the positive displacement blower, and so the two are a common combination for positive pressure pneumatic conveying systems. The upper limit on the pressure capability of the rotary valve is dictated primarily by the problem of air leakage across the valve.

Developments in the mid 1980’s by a couple of companies, and since by numerous others, have greatly extended the range of operating pressure for rotary valves, as indicated on Figure 2.2. The use of rotary valves is rather limited for abrasive materials, however, owing to problems of erosive wear. This is particularly the case for positive pressure conveying systems, since air leakage across the valve aggravates the wear problem considerably.

2.1 Drop-Through Valve

The type of valve described above is usually referred to as a ‘drop-through’ feeder and is depicted in Figure 2.3 This type of feeder is generally suitable for free flowing materials. Material from the supply hopper continuously fills the rotor pockets at the inlet port which is situated above the rotor. It is then transferred by the motor driven rotor to the outlet where it is discharged and entrained into the conveying line.

2.1.1 Valve Wear

By the nature of the feeding mechanism, rotary valves are more suited to relatively non-abrasive materials. This is particularly the case where they are used to feed materials into positive pressure conveying systems. By virtue of the pressure difference across the valve, and the need to maintain a rotor tip clearance, air will leak across the valve. Wear, therefore, will not only occur by conventional abrasive mechanisms, but by erosive wear also.

Air leakage through the blade tip clearances can generate high velocity flows, which will entrain fine particles, and the resulting erosive wear can be far more serious than the abrasive wear. Wear resistant materials can be used in the construction of rotary valves, and removable lining plates can be incorporated to help with maintenance, but wear can only be minimized, it cannot be eliminated if an abrasive material is to be handled.
2.2 Alternative Designs

As the rotary valve is probably the most common feeding device in use, it is not surprising that much effort has gone into to developing it further. The improvement in materials and construction methods to make it more acceptable for handling abrasive materials is one such area.

The reduction in air leakage and the development of a rotary valve capable of operating at much higher pressures, and across much higher pressure differentials, has been another. Its capability for handling a wider range of materials was an early development.

2.2.1 Off-Set Valve

Rotary valves that have an off-set inlet, and hence a corresponding off-set outlet for material feed, are often employed in applications where shearing of the material should be avoided. This is particularly a problem where the material has a large proportion of large particles. A typical valve is given in Figure 2.4.

They employ a side inlet, generally with an adjustable flow control, so that the angle of flow of the material does not permit the rotor pocket to be completely filled. As the rotor rotates toward the housing, material flows into the trough of the rotor and so prevents shearing. This type of valve is widely used for feeding pelleted materials.

2.2.2 Blow-Through Valve

Another variation of the standard type of feeder is the ‘blow-through’ valve, which is also shown in Figure 2.4.
Figure 2.4 Alternative rotary valve configurations. (a) Off-set and (b) blow-through.

With the blow-through valve the conveying air passes through and purges the discharging pockets such that the material entrainment into the conveying pipeline actually takes place in the valve itself. These valves are primarily intended for use with the more cohesive types of material, since this type of material may not be discharged satisfactorily when presented to the outlet port of a ‘drop-through’ valve.

It should be borne in mind that for an eight bladed rotor, such as that shown in Figure 2.3 rotating at a typical speed of 20 revolutions per minute, a time span of only 0.375 seconds is available for the material to be discharged from each pocket. The importance of feeding material into a pipeline as smoothly as possible was mentioned above, and it was stated that in a dilute phase conveying system the air would traverse a 400 ft long pipeline in about six seconds. For the rotary valve being considered, about 13 pockets of material would be deposited into the pipeline in this period.

In fuel firing systems this is not likely to acceptable as it will result in significant pulsing of the flame in the furnace. If a rotary valve is to be used in this type of application it would be recommended that a helical or twisted rotor be used so that the material is deposited into the pipeline at a more uniform rate.

A blow-through valve would not be recommended for the feeding of abrasive materials. This is a very turbulent region and the rotor blades, and rotor housing near the point of entry to the pipeline, would be prone to very severe wear. End plates could not be employed on the rotor very conveniently with this arrangement and so the pressure capability would be limited.

2.3 Air Leakage

It is an unavoidable physical characteristic of the rotary valve that, in a positive pressure pneumatic conveying system, there will be a leakage of air across the valve, via the returning empty pockets and the various rotor blade clearances. Typical air flows and leakage paths for a rotary valve system are shown in Figure 2.5.

Copyright © 2004 by Marcel Dekker, Inc. All Rights Reserved.
For a 4 inch bore pipeline the air leakage, $V_L$, could be as much as 15% of the air supplied. For a material such as plastic pellets it will be even higher, since the material itself offers little resistance to air flow, and in smaller diameter pipelines the percentage will be proportionally greater. For a valve operating across a small pressure difference with a very fine material, however, air leakage will be significantly reduced.

The magnitude of the loss will depend upon the pressure difference across the valve, the valve size, the rotor tip clearance, the nature of the material being handled, and the resistance to air flow by the head of material over the valve. If air leakage across the valve is not taken into account, or if the anticipated leakage is incorrect for some reason, it can have a marked effect on the performance of the conveying line.

If insufficient air is available for conveying the material in the pipeline, as a result of losses across a rotary valve, it is possible that the pipeline will block, for a loss of 10 to 20% of the total air supply will significantly affect the velocity of the air in the conveying system. Also, if two or more rotary valves feed into a common line, and there is no additional valve over each rotary valve to minimize air losses from those not in use, the air, and hence energy loss, could be very considerable.

Rotor tip clearance is an important variable here. The gradual wear of a valve in use, such that the rotor clearances increase slightly over a period of time, will affect the balance of the air flows shown in Figure 2.5, and consequently af-
fect the conveying line performance with respect to time. This is one of the rea-
sons why rotary valves are not generally recommended for the handling of abra-
sive materials. It is important, therefore, that rotary valves should be well main-
tained, and if they are to be used for abrasive products they should incorporate
wear resistant materials.

2.3.1 Air Venting

Unless the air leakage across the rotary valve is vented away, prior to the material
entering the valve, material flow into the valve may be severely restricted by the
upward flow of air. This air flow may also result in a change in bulk density of the
material. The magnitude of the problem depends very much upon the properties of
the material being handled.

For plastic pellets and granular materials, venting may not be necessary, but
for fine cohesive materials and light fluffy materials the volumetric efficiency of
the valve, in terms of pocket filling, may be very low. In this case material feed at
a controlled rate might be difficult to achieve. A number of different ways of vent-
ing rotary valves are presented in Figure 2.6.

Since the vented air will contain some fine material, this is normally di-
rected back to the supply hopper, or to a separate filter unit. Because there will be
a carry-over of material this filter must be a regularly cleaned unit, otherwise it
will rapidly block and cease to be effective. Indeed, the pipe connecting the vent to
the filter must be designed and sized as if it were a miniature pneumatic conveying
system, in order to prevent it from getting blocked.

Figure 2.6 Methods of venting rotary valves. (a) Internal vent, (b) external vent, and
(c) pellet vent.
2.4 Entrainment Devices

Owing to the pulsating nature of the material flow at outlet from the valve, with the individual pockets of material discharged from the rotor, the change in direction of the material flow, and the flow of leakage air against the direction of material flow, the region beneath a rotary valve is particularly turbulent. In order to reduce the turbulence level, and hence energy loss, entrainment devices are often used under the rotary valve. A common device is a ‘drop-out’ box and this is illustrated in Figure 2.7a.

Another configuration is the venturi entrainment section, and this is shown in Figure 2.7b. Here the cross-sectional area of the air supply pipeline is reduced by means of a convergent section immediately prior to the rotary valve. As a result there is a corresponding increase in entrainment velocity and hence a decrease in pressure in the region beneath the valve. A consequence of this decrease in pressure is that there will be less air leakage through the valve to interfere with material feeding.

This should result in an improvement in performance when handling the finer, free flowing types of material. A divergent section allows the kinetic energy of the high velocity air to be re-converted back to pressure. This type of device would not be recommended for abrasive or friable materials, however, because of the increase in air velocity and turbulence generated in the area.

2.5 Rotor Types

Rotors are either of the ‘open-end’ type or ‘closed-end’ type. With ‘open-end’ types the blades are welded directly to the driving shaft, whilst with the ‘closed-end’ type discs or shrouds are welded to the shaft and blade ends to form enclosed pockets. These two types of rotor are illustrated in Figure 2.8.
2.5.1 High Pressure Designs

The closed-end type of rotor provides a very much more rigid construction, and it is with this type of rotor that developments to much higher pressure applications have been possible. With an end plate it is possible to provide a seal to significantly reduce the quantity of air that leaks across the valve by this route, and a more rigid construction allows rotor tip clearances to be reduced. The reduction in air flow, and more particularly material, past the rotor end plate also provides added protection for the bearings.

Air leakage via the returning empty pockets remains a problem and leakage via the blade tip clearances will still occur. By these various improvements, however, the operating pressure differential has been improved to about 45 to 60 lbf/in\(^2\), compared with about 15 lbf/in\(^2\) for the conventional rotary valve, as indicated earlier on Figure 2.3.

2.5.2 Pocket Types

There are two rotor pocket configurations in widespread use, and these are shown in Figure 2.9. The most common type has deep pockets and hence maximum volumetric displacement. This is more suited to the handling of free flowing materials.
The second type has shallow, rounded pockets and so its volumetric capacity is reduced. This configuration is generally used with the more cohesive types of material that tend to stick in deep pockets. All angles are eliminated by creating the more rounded profile. Blade tips are often employed, and a sketch of such a rotor is given in Figure 2.9c. Many of these are adjustable to maintain operating efficiency. They can be made of resilient, spark-proof, flexible or abrasion resistant materials.

2.5.3 Rotor Clearance

The rotor clearance can have a significant effect on valve performance, and in an attempt to minimize the effect of the leakage on the feed rate, manufacturers make these clearances as small as possible. Clearances on new valves are typically of the order of 0.003 to 0.006 inch. Clearances smaller than this would add considerably to the cost of manufacture and may even lead to binding in the housing due to deflection of the rotor, or movement within the bearings, when subject to the applied pressure gradient.

Particular care with respect to binding must be taken if the material to be handled is hot, because differential expansion of rotor and casing could cause the valve to seize up. The fitting of flexible elastomer/polymer wipers to the rotor blades, such that they are in contact with the housing, is quite common. This approach, however, is generally limited to low pressure applications, typically up to about 4 lbf/in$^2$ gauge, since the leakage at pressure gradients greater than this can deflect the wipers and so lose the advantage.

2.5.4 Blade Numbers

The number of blades on the rotor will determine the number of blade labyrinth seals that the air must pass before escaping from the system. From an air loss point of view, therefore, a ten bladed rotor would be specified for applications with pressure differentials from 8 to 15 lbf/in$^2$. Eight bladed rotors are commonly used in applications with pressure differentials up to 8 lbf/in$^2$, and six bladed rotors where the pressure differential is below 3 lbf/in$^2$.  

Figure 2.9 Rotor pocket configurations. (a) Deep pocket rotor, (b) shallow pocket rotor, and (c) rotor with blade tips.
There is obviously a practical limitation to the number of blades that can be used in a rotor when handling a given material. The number is largely dependent upon the material itself, since increasing the number of blades decreases the angle between them. A decrease in this angle is sufficient with some materials to prevent it from being discharged when presented to the outlet port.

2.6 Feed Rate

The feed rate of a rotary valve is directly proportional to the displacement volume of the rotor and its rotational speed. The displacement volume is simply the pocket size or volume multiplied by the number of rotor pockets. If a mass flow rate of material is required this must then be multiplied by the bulk density of the material. The constant of proportionality here is the volumetric efficiency of the rotary valve.

2.6.1 Pocket Filling Efficiency

If air leakage impedes material flow, the pockets will not fill completely and so the volumetric efficiency will be reduced. Air leakage may also have the effect of reducing the bulk density of the material, for with some materials the fluidized bulk density can be very much lower than the 'as poured' bulk density. It should be noted that, because of air leakage, the volumetric efficiency of a rotary valve when feeding a negative pressure system will generally be much greater than when feeding a positive pressure system.

2.6.2 Feed Rate Control

As the rotary valve is a positive displacement device, feed rate control can be achieved quite simply by varying the speed of the rotor. The pocket filling efficiency of a rotary valve, however, is also a function of rotor speed. Up to a speed of about 20 rev/min the filling efficiency is reasonably constant, but above this speed it starts to decrease at an increasing rate. Thus there is a limit on feed rate for a given rotary valve. Rotary valves, however, do come in a very wide range of sizes to meet almost any duty.

2.7 Feeding Negative Pressure Systems

With negative pressure conveying systems there is no adverse pressure gradient across the material feeding device and so the leakage of air across the valve will not be a problem, as it will not occur. The valve will not have to be designed to withstand a pressure difference, or be manufactured to provide fine blade tip clearances. As a consequence a rotary valve for a negative pressure conveying system is likely to be very much cheaper than for a positive pressure system.

It must be emphasized, however, that under no circumstances should a rotary valve designed for a negative pressure conveying system be used in a positive pressure conveying system. Since there is no air leakage across the valve, air vent-
ing is not required, and erosive wear will not be a problem with the handling of abrasive materials, although the abrasive wear element will remain.

2.7.1 Rotary Air Locks

With negative pressure conveying systems the reception vessel will be maintained under vacuum. Rotary valves, or rather rotary air locks in this case, are often used for the discharge of materials from such reception hoppers. If discharge occurs while conveying takes place, and the vessel is under vacuum, there will be a leakage of air across the valve, in exactly the same way as air will leak across a rotary valve when feeding a positive pressure conveying system.

Although the leakage of the air across the rotary air lock into the reception vessel will not influence the feeder in any way, the air that leaks across the rotary air lock will result in the conveying line being starved of air. Exhausters are specified for a given duty, and so if air leaks into the system such that it by-passes the conveying pipeline, the conveying line inlet air velocity will be reduced as a consequence. If the air ingress rate is too high, such that the conveying line inlet air velocity falls below the minimum conveying air velocity for the material, the pipeline is likely to block.

3 SCREW FEEDERS

Much of what has been said about rotary valves applies equally to screw feeders, with respect to both positive pressure and vacuum conveying systems. They are positive displacement devices and so feed rate control can be achieved by varying the speed. They can be used for either positive pressure or vacuum pipeline feeding duties. Air leakage is a problem when feeding into positive pressure systems, and they are prone to wear by abrasive materials.

There are two basic types of screw feeder: the simple screw feeder and the variable pitch device, and the two types have very different capabilities with regard to pipeline feeding.

3.1 The Simple Screw Feeder

A simple type of screw feeder is shown in Figure 2.10. Rotation of the screw moves a continuous plug of material into the pipeline, where it is dispersed and entrained with the conveying air. A particular advantage of screw type feeders is that there is an approximate linear relationship between screw speed and material feed rate, and so the discharge rate can be controlled to within fairly close limits.

The simple type of screw feeder, however, is rarely used for feeding positive pressure conveying systems. This is because there is little in their design to satisfy the basic requirement of feeding across an adverse pressure gradient. Air leakage represents a major problem with many materials, and so they are generally limited to vacuum systems where operating pressure differentials are not a concern.
3.2 Variable Pitch Screw Feeder

The simple screw feeder has been developed by several companies into a device that can feed successfully into conveying lines at pressures of up to about 35 lbf/in² gauge. One such device, which was manufactured by the Fuller Company of the USA, and known as a Fuller-Kinyon pump, or screw pump, is shown in Figure 2.11.

Copyright © 2004 by Marcel Dekker, Inc. All Rights Reserved.
The main feature of these screw feeders is that the screw decreases in pitch along its length. By this means the material to be conveyed is compressed to form a tight seal in the barrel. These feeders used to be widely used in the cement industry, and for fly ash conveying in power stations. The material is fed from the supply hopper and is advanced through the barrel by the screw.

Since the screw pitch decreases towards the outlet, this compacts the material as it passes through the barrel. This is sufficient to propel the plug through the pivoted non-return valve at the end of the barrel and into a chamber into which air is continuously supplied through a series of nozzles. A pressure drop of about 7 lbf/in² must generally be allowed for the air across these nozzles, which adds significantly to the power requirement.

A screw having a decreasing pitch does, however, require a very high power input for the feeder. For a given feed rate a screw pump might require a 100 hp motor for the screw drive, compared with about 5 hp for a rotary valve, and effectively zero power for a blow tank system. For high pressure operation the device is only suitable for materials that can be compressed, which generally restricts their use to materials that have very good air retention properties, such as cement and fly ash.

Both fly ash and cement are abrasive materials and so maintenance of such a feeder is a problem in industries that demand long operating periods between planned maintenance shut-downs. As a consequence of the high power demand and wear problems, the market for this type of feeder has reduced in recent years. It is often used, however, where high pressure, closed loop conveying of fine, potentially combustible materials, is required.

4 VENTURI FEEDERS

Since one of the basic problems with feeding positive pressure conveying systems is that the air leakage arising from the adverse pressure gradient can interfere with the flow of material into the pipeline, this situation can be improved by using venturi feeders. These basically consist of a reduction in pipeline cross-section prior to the region where the material is fed from the supply hopper, followed by a divergent section, as shown in Figure 2.12.

A consequence of this reduction in flow area is an increase in the entraining air velocity and a corresponding decrease in pressure in this region. With a correctly designed venturi the pressure at the throat should be the same, or just a little lower, than that in the supply hopper which, for the majority of applications, will be atmospheric pressure. This then encourages the material to flow more readily under gravity into the pipeline, since under these conditions there is no leakage of air in opposition to the material feed.

In order to keep the throat at atmospheric pressure, and also of a practical size that will allow the passage of material, and for it to be conveyed, a relatively low limit has to be imposed on the air supply pressure.
These feeders, therefore, are usually incorporated into systems that are required to convey free flowing materials at low flow rates over short distances. Since only low pressures can be used with the basic type of venturi feeder shown in Figure 2.12, a standard industrial type of fan is often all that is needed to provide the air requirements.

4.1 Commercial Venturi Feeder

To fully understand the limitations of this type of feeder the thermodynamic relationships need to be followed and these are presented in most standard textbooks on the subject. In a 4 inch bore pipeline, with air supplied at 3 lbf/in² gauge, for example, the throat diameter would have to be about 1½ inch. Although venturis capable of feeding materials into conveying systems with operating pressure drops of 5 lbf/in² are commercially available, the pressure drop across the venturi can be of the same order. Such a venturi is shown in Figure 2.13.

Copyright © 2004 by Marcel Dekker, Inc. All Rights Reserved.
This means that the air supply will have to be at about 10 lbf/in$^2$ gauge and consequently the air will have to be supplied by a positive displacement blower. Since there are no moving parts these feeders are potentially suitable for abrasive and friable materials. Care must be exercised in using venturis to feed such materials into the conveying line for the very high air velocity in the throat may lead to considerable erosion and particle degradation in this region. If abrasive materials have to be conveyed, a verturi feeder fitted with a replaceable wear resistant liner would be recommended. Experience has shown that these feeders are best suited to the handling of free flowing materials. Care must be taken, however, to continuously control the flow of materials, otherwise a blockage may occur.

4.2 Feed Control

It will be seen that there are no moving parts with this type of feeding device, which has certain advantages with regard to wear problems, but there is no inherent means of flow control either, and so this has to be provided additionally. This means that the venturi could be fed from a belt, screw, rotary valve or vibratory feeder.

A screw or vibratory feeder could be very elementary devices since there will be no problems of pressure differential and air leakage. Alternatively a supply hopper could be used if fitted with a trickle valve (as illustrated in Figure 2.13), a calibrated orifice plate or a gate/slide valve, provided that this type of device provides a suitable degree of control for the material to be fed.

5 GATE LOCK VALVES

These are probably the least used of all devices for feeding pneumatic conveying system pipelines. They are variously known as double flap valves, double dump valves, and double door discharge gates. They basically consist of two doors or gates that alternately open and close to permit the passage of the material from the supply hopper into the conveying line. The operating sequence is illustrated in Figure 2.14.

These gates may be motor driven, cam or air cylinder operated, or may work under gravity. The air which passes the lower gate from the conveying pipeline is vented so that it does not interfere with the material about to flow through the upper gate, in positive pressure systems. As with rotary valves, the blower or compressor should be sized to allow for this leakage, although this is not as effective in this case, as there is an order of magnitude in difference in the operating frequency.

Like the venturi feeder, care must be taken to ensure that the material is metered into the gate lock since it will cease to function correctly under a head of material, as would be the case if it was situated directly beneath the outlet of the supply hopper. A typical commercial type of gate valve feeder is shown in Figure 2.15.
Although the device is capable of providing a controlled feed rate, it is very much an intermittent feeder. The gate lock feeder typically operates at between 10 and 15 cycles per minute. In contrast, the rotary valve has approximately 150 to 200 discharges per minute from its pocketed rotor.

Figure 2.14  Operating sequence of gate lock valves.

Figure 2.15  Commercial type of gate valve feeder.
Such a frequency is relatively slow and would result in a constantly fluctuating conveying line inlet air pressure. In order to maximize material flow rate through a conveying pipeline the air supply pressure needs to remain reasonably constant. As a consequence the efficiency of conveying is reduced.

This reduction in the number of discharges also means that the air supply, in terms of flow rate, and particularly pressure, must be correctly evaluated to prevent the possibility of line blockage. With few moving parts this type of feeder can be used to feed friable materials, and with appropriate materials of construction it is also suited to the handling of abrasive materials.

They are often used to feed large granular materials, but they should be of a robust construction. Care must be exercised to prevent large particles from getting trapped in the gates and causing them to buckle or deflect. If the gates cease to seat correctly, a large proportion of the conveying air could be lost through the venting system which could result in pipeline blockage.

The same situation will occur if large particles jam in the gate and prevent its complete closure. Once again, this is only a serious problem with positive pressure conveying systems.

6 SUCTION NOZZLES

A specific application of vacuum conveying systems is the pneumatic conveying of bulk particulate materials from open storage and stockpiles, where the top surface of the material is accessible. Vacuum systems can be used most effectively for the off-loading of ships and for the transfer of materials from open piles to storage hoppers.

They are particularly useful for cleaning processes such as the removal of material spillage and dust accumulations. In this role they are very similar to the domestic vacuum cleaner. For industrial applications with powdered and granular materials, however, the suction nozzles are rather more complex.

It is essential with suction nozzles to avoid filling the inlet tube solidly with material, and to maintain an adequate flow of air through the conveying line at all times. To avoid blocking the inlet pipe, sufficient air must be available at the material feed point, even if the suction nozzle is buried deep into the bulk solid material.

Indeed, the vacuum off-loading system must be able to operate continuously with the nozzle buried in the material at all times in order to maximize the material flow rate. Sufficient air must also be available for conveying the material through the pipeline once it is drawn into the inlet pipe. In order to obtain maximum output through a vacuum line it is necessary to maintain as uniform a feed to the line as possible.

To satisfy these requirements two air inlets are required, one at the material pick-up point and another at a point downstream. A typical suction nozzle for vacuum pick-up systems is shown in Figure 2.16.
6.1 Feed Rate Control

The suction nozzle is provided with an outer sleeve at its end, and primary air for material feed is directed to the conveying line inlet in the annular space created. The length ‘a’ of this sleeve has to be long enough to ensure that it is not buried by the movement of the material and so prevent the flow of primary air. This sleeve may be many feet long for a ship off-loading application. The position of the end of the sleeve relative to the end of the pipeline, ‘b’, is mostly material dependent, and could be positive or negative. This dictates the efficiency with which the material is drawn into the conveying line.

Secondary air for conveying the material is generally introduced via a series of holes in the pipeline. Some form of regulation of both the primary and secondary air is necessary, and the proportion of the total which is directed to the material inlet is particularly important. This is also material dependent, in a similar way to the proportion of the total air supply which is used in a blow tank for control of the discharge rate into the pipeline. In a way, the vacuum nozzle is very similar to a blow tank. Neither of them have any moving parts, but by proportioning the air between primary and secondary supplies, total control can be achieved over material feed rate. This is discussed in more detail in a later section of this chapter on blow tanks.

6.2 Flow Aids

The end of the pipeline at the material inlet point is often fabricated into a rectangular shape for manual applications in order to facilitate more effective surface cleaning. Many variations in shape and design are possible, including the use of
multiple ‘tails’ to a common suction line. In the case of large scale vacuum sys-
tems, such as ship off-loading, it is often necessary to attach mechanical dredging
and paddle devices to the end of the nozzle. This is particularly so if materials with
poor flow properties have to be unloaded, for it is essential to maintain a continu-
ous supply of material to the nozzle to achieve the maximum potential of a vac-
uum line.

6.3 Hopper Off-Loading

Although suction nozzles are generally associated with mobile systems such as for
spillage clearance and ship off-loading applications, they can equally be used in
fixed systems for the emptying of hoppers and silos. In this application the nozzle
is usually positioned in the bottom of the hopper and a typical arrangement is illus-
trated in Figure 2.17

The vacuum nozzle is generally fitted into the hopper via a sleeve so that it
can be easily removed when required. The controls over the primary and sec-
dary air are also arranged to be external to the hopper, and very often the location
of the inner tube with respect to the outer tube can also be adjusted external to the
hopper. For these reasons a section of flexible hose is often incorporated into the
conveying pipeline close to the hopper.

7 TRICKLE VALVES

These are only suitable for negative pressure conveying systems, since there is no
pressure drop against which to feed. The greatest problem with this class of feeder
is that of flow rate control.

![Diagram of vacuum nozzle application to hopper off-loading.](image)

**Figure 2.17** Application of vacuum nozzles to hopper off-loading.
Control is generally achieved by calibration and adjustment on site, but this is very material dependent. A slight change in particle size, particle shape or moisture content will affect the balance of the setting for the material and change the flow rate. With this type of feeder it is usual to have a short length of pipeline prior to the material feed point and to choke this at the inlet. By this means a slight negative pressure will be generated beneath the hopper, which will mean that there will be a slight pressure gradient in the direction of material feed, and this will encourage the flow of material into the pipeline.

8 BLOW TANKS

In recent years blow tanks have become more widely used, but there is a lot of uncertainty as to how they operate, how they can be controlled and how they might be specified for a given duty. There are also a large number of different types and configurations available. They are rarely available as a standard piece of equipment that can purchased from a catalog, like a rotary valve, and are generally supplied as part of a package for a complete conveying system.

8.1 Introduction

Blow tanks are often employed in pneumatic conveying systems because of their capability of using high pressure air. A high pressure air supply is necessary if it is required to convey over long distances in dilute phase, or to convey at high mass flow rates over short distances through small bore pipelines. Blow tanks are neither restricted to dense phase conveying nor to high pressure use.

Materials not capable of being conveyed in dense phase can be conveyed equally well in dilute phase suspension flow from a blow tank. Depending upon their pressure rating, blow tanks generally have to be designed and manufactured to an appropriate pressure vessel code, and are subject to insurance and inspection. They can, therefore, be more expensive than alternative feeding systems.

8.1.1 Low Pressure Systems

Low pressure blow tanks are often used as an alternative to screw feeders and rotary valves for feeding pipelines, particularly if abrasive materials have to be conveyed. The blow tank has no moving parts and so both wear of the feeder and degradation of the material are significantly reduced. Low pressure blow tanks operating with positive displacement blowers, for example, do not usually need to be coded vessels and so the cost of this type of blow tank can be much lower as a consequence.

Another advantage of these systems is that the blow tank serves as both the hopper and feeder, and so the problems associated with feeding against an adverse pressure gradient, such as air leakage, do not arise. There will, however, be a small pressure drop across the blow tank in order to discharge material into the pipeline,
and so this must be taken into account when evaluating air requirements. There will also be a need to vent the blow tank when it is filled with material.

8.1.2 Blow Tank Control

In most blow tank systems the air supply to the blow tank is split into two streams. One air stream pressurizes the blow tank and may also fluidize or aerate the material in the blow tank. This air stream serves to discharge the material from the blow tank. The other air stream is fed directly into the discharge line just downstream of the blow tank. This is generally referred to as supplementary air and it provides the necessary control over the material flow in the conveying line. More detailed information is provided later in this chapter.

8.2 Basic Blow Tank Types

There are numerous different types of blow tank, and for each type alternative configurations are possible. The basic features of different blow tanks are essentially similar, but different arrangements can result in very different conveying capabilities and control characteristics.

8.2.1 Top and Bottom Discharge

The blow tank shown in Figure 2.18 is a top discharge type. Discharge is arranged through an off-take pipe which is positioned above the fluidizing membrane. With this type of blow tank, however, it is not possible to completely discharge the contents, although with a conical membrane very little material will remain.

Figure 2.18 Top discharge blow tank with fluidizing membrane.
In a bottom discharge blow tank there is no membrane and material is gravity fed into the pipeline, and so the contents can be completely discharged. Such a blow tank is shown in Figure 2.19.

Top and bottom discharge generally refers only to the direction in which the contents of the vessel are discharged. This simple classification, however, can become confused by the considerable number of different configurations that are used to admit air to the blow tank and to the conveying line.

A number of alternative top and bottom discharge blow tank types, with and without fluidizing membranes, are shown in Figure 2.20, and a number of alternative bottom discharge arrangements are shown in Figure 2.21. This is by no means a definitive group for there are a considerable number of other possibilities. Many companies like to adopt a particular configuration that is recognizable as a specific product of their company.

Figure 2.20 Alternative top discharge blow tank arrangements. (a) With fluidizing membrane, (b) with conical off-take pipe and (c) with aerated base.
Figure 2.21 Alternative bottom discharge blow tank arrangements. (a) With air inlet to top only, (b) with air to top and pipeline and (c) with two air supplies at base.

In Figures 2.20a and c, and 2.21c the material is aerated or fluidized, by means of a porous membrane in the first case, and via a narrow annular gap in the other two. In some cases an additional air supply is taken directly to the entrance of the off-take pipe to provide further fluidization in this region. This is sometimes necessary for materials with very poor air retention, for they could block the discharge pipe if only a small percentage of the total air supply is directed to the blow tank for aerating the material and pressurizing the blow tank.

In some of the blow tanks illustrated only one air supply line is used. The application of these types is strictly limited since little control can be exercised over material flow rate, unless air is introduced into the pipeline downstream of the blow tank via trace lines or boosters. In general the top discharge type with fluidization of the material is most suitable for powdered materials, and bottom discharge blow tanks are best suited to granular materials.

8.2.1.1 Fluidizing Membranes
Fluidizing membranes may consist of a porous plastic, a porous ceramic, or a filter cloth sandwiched between perforated metal plates. A perforated metal plate is required beneath the membrane in order to support the mass of fluidized material that it has to carry. A perforated metal plate is needed above the membrane in order to provide support against the pressure of fluidizing air from beneath. If a porous membrane is used it is important that the fluidizing air is both clean and dry, for dust and moisture in the air will cause a gradual deterioration in performance.

In top discharge blow tanks it is not usually necessary for the discharge pipe to have a conical end, unless additional fluidization is required in this region. A typical arrangement is shown in Figure 2.22. For powdered materials the off-take pipe needs to be spaced about two inches above the base or membrane. If it is further away the blow tank will simply discharge less material and hence reduce its effective capacity. If it is too close it may adversely affect the discharge rate.
8.2.2 Blow Tank Pressure Drop

The pressure drop across the blow tank represents a potential source of energy loss to the conveying system and so should be kept as low as possible. In the case of top discharge blow tanks this is particularly important. The discharge pipe must be kept as short as possible because the pressure gradient in this line will be very high owing to the very high material concentration. Supplementary air should be introduced immediately above the blow tank, as shown in Figures 2.18 and 2.20c.

With very large blow tanks the discharge pipe should be turned through 90° just above the membrane and be taken through the side of the vessel if necessary. Alternatively the supplementary air should be introduced within the blow tank, and be fed into the discharge pipe close to the membrane end in the style of a vacuum nozzle. If the discharge pipe is kept to about six feet long the pressure drop across the blow tank will be about 3 lb/in², which includes the membrane resistance. In the case of bottom discharge blow tanks, very short discharge lines can usually be arranged and so the pressure drop is generally no more than about 1½ lb/in².

8.2.3 Road and Rail Vehicles

Many road and rail vehicles used for the transport of bulk solids are essentially blow tanks. In the case of road tankers the vehicle usually has its own air supply for off-loading. These are generally rated at a pressure of about 15 lb/in² gauge and positive displacement blowers are used for the purpose. Rail vehicles generally rely on a site supply for off-loading, with a much higher pressure capability.

Figure 2.22 Sketch of straight end discharge pipe.
8.3 Single Blow Tank Systems

A particular problem with single blow tank systems is that conveying is not continuous, as it can be with rotary valve and screw feeding systems. In order to achieve an equivalent material mass flow rate, therefore, steady state values of the flow rate during conveying have to be somewhat higher. This point was illustrated earlier with Figure 1.8.

8.3.1 Blow Tanks Without a Discharge Valve

The simplest form of blow tank is one which has no discharge valve. Such an arrangement is illustrated in Figure 2.23. This is shown in a top discharge configuration with a fluidizing membrane, but could equally have been shown in any of the arrangements given in Figures 2.18 to 2.21. With abrasive materials the discharge valve is particularly susceptible to wear and so the possibility of operating a blow tank without such a valve can be a considerable advantage.

Although there is no valve in the material discharge line, other valving is necessary. A valve is required to isolate the blow tank from the material supply hopper, so that the blow tank can be pressurized, and a vent line valve is needed for venting the blow tank whilst filling from the hopper. These valves are either fully open or closed. Valves, or possibly flow restrictions or orifices, are required in the air supply lines in order to provide the necessary degree of control over the material discharge rate from the blow tank.

Figure 2.23 Single blow tank without discharge valve.
Operation without a discharge valve will present no operational problems for top discharge blow tanks but the possibility of such an arrangement with bottom discharge blow tanks depends upon the material being fed. Fine, free flowing materials are likely to flood feed, with the possibility of blocking the pipeline on start up.

8.3.1.1 Conveying Cycle Analysis

With the arrangement shown in Figure 2.23 the blow tank starts to pressurize as soon as the vent line valve is closed. Both the blow tank and conveying line have to be pressurized before any material is delivered from the pipeline and this process can take a significant proportion of the total cycle time. Even when the material is first discharged from the conveying line, the pressure, and hence conveying rate, have still to reach steady state values. The pressure builds up gradually as more material is conveyed, but it is a relatively slow process.

Towards the end of the conveying cycle, when the blow tank has almost been discharged, the blow tank has to be de-pressurized and the entire conveying line has to be cleared of material and vented. This process also takes a significant amount of time, particularly if the pipeline is long. The time required to fill the blow tank and set the valves has to be taken into account in addition. This type of blow tank system, however, is very easy to operate and maintenance costs are very low.

8.3.2 Blow Tanks With Discharge Valves

If there is a valve on the blow tank discharge line, and control valves on the supplementary and fluidizing air supply lines, the blow tank can be pressurized in a shorter space of time if all the air available is directed to the blow tank, and discharge is prevented until the steady state pressure is reached. This time can be shortened further if an additional air supply is available for the purpose, but the cost and complexity would be considerable, and the benefits obtained would probably be marginal.

When the blow tank discharge valve is opened the control valves on the supplementary and fluidizing air supply lines must be returned to their settings for conveying. This is essential, for the correct air flows must be maintained to achieve satisfactory blow tank discharge and material conveying at the desired rate. In the blow tank without a discharge valve these settings are rarely changed, and this is why it takes so long to achieve steady state conveying, particularly if the material is conveyed in dilute phase.

8.3.2.1 Blow Tank Venting

If there is a vent line between the blow tank and the supply hopper it will also be possible to reduce the time required for de-pressurizing the system. As soon as the blow tank is empty, the discharge valve should be shut and the vent line opened. It will also be necessary to shut the blow tank fluidizing air supply valve and fully open the supplementary air supply valve. By this means the blow tank can be iso-
lated from both the air supply and the conveying line, and the processes associated with each can be carried out simultaneously.

By this means the blow tank can be de-pressurized very quickly in isolation from the conveying line. The total air supply will still be available to the pipeline so that this can be purged separately, and at the same time. This will also prevent the large volume of air in the blow tank from expanding rapidly through the conveying line, thereby causing very high air velocities and possible severe pipeline erosion during the venting process if the conveyed material is abrasive.

Isolation of the blow tank will also reduce the loading on the filtration unit at this time in the conveying cycle. It is important that this surge of air at the end of the cycle is taken into account when sizing the filters for the plant, regardless of the mode of blow tank operation, but particularly if the blow tank is not vented in isolation. If the blow tank is vented to the supply hopper it is equally essential that the filter on the supply hopper is also correctly sized for the anticipated volumetric flow rate.

8.4 Twin Blow Tank Systems

If two blow tanks are used, rather than one, a significant improvement in performance can be achieved. There are two basic configurations for twin blow tanks. One is to have the two in parallel and the other is to have them in series.

8.4.1 Twin Blow Tanks in Parallel

The ratio of the mean flow rate to the steady state material flow rate can be brought close to unity if two blow tanks in parallel are used. While one is feeding material into the conveying pipeline, the other can be de-pressurized, be filled with material, and be pressurized, ready for discharging when the other blow tank is empty. By this means almost continuous conveying can be achieved through a common pipeline.

This arrangement, however, requires a full set of discharge, vent and isolating valves for each blow tank and an automatic control system to achieve the optimum timing. In some plants three blow tanks are utilized. A typical twin blow tank arrangement is shown in Figure 2.24 The sequence of events would be as follows:

- Blow Tank A
  - fill
  - pressurize
- Blow Tank B
  - discharge
  - vent
  - fill
  - pressurize

Copyright © 2004 by Marcel Dekker, Inc. All Rights Reserved.
From this it can be seen that the blow tank pressurizing process in one blow tank has to be carried out while the material is being discharged from the other. This would require additional air and, once again, it would probably not be economically viable for the marginal improvement obtained. To achieve a high material flow rate with a single blow tank, a fairly large blow tank would be needed, but with twin blow tanks the blow tank size can be smaller. The size can be based on a reasonably short blow tank cycle, provided that the two sets of sequences can be fitted into the time available.

8.4.2 Twin Blow Tanks in Series

If two pressure tanks are placed vertically in line beneath a hopper it is possible to use a high pressure air supply for the continuous conveying of a material. A typical arrangement is shown in Figure 2.25. The vessel between the hopper and the blow tank transfers the material between these two, and is effectively a lock hopper. The vent line is used to release the pressure in the transfer vessel, in addition to venting on filling.

The lock hopper, or transfer vessel, is filled from the hopper above. The lock hopper is then pressurized to the same pressure as the blow tank, either by means of a pressure balance from the blow tank, which acts as a vent line for the blow tank while it is being filled, or by means of a direct line from the main air supply. With the transfer vessel at the same pressure as the blow tank, the blow tank can be topped up to maintain a continuous flow of material.
2.25 Blow tank system capable of continuous operation.

The lock hopper, however, will have to be pressurized slowly in order to prevent a loss in performance of the system while it is conveying material. The blow tank in Figure 2.25 is shown in a top discharge configuration, but without a fluidizing membrane. The air enters a plenum chamber at the base, to pressurize the blow tank and fluidize the material, and is discharged via an inverted cone into the conveying line. Twin blow tanks, with one positioned above the other, do require a lot of headroom, and so the blow tank arrangement shown in Figure 2.25 is sometimes employed to minimize the head required.

8.4.2.1 Alternative Feeding Arrangements

If a lock hopper arrangement is used, as shown in Figure 2.25, the pipeline feeding device need not be a blow tank at all, despite the use of high pressure air. With the transfer pressure vessel separating the hopper and the pipeline feeding device, the feeding device can equally be a rotary valve or a screw feeder, for there is little pressure drop across the feeder. The pressure drop is, in fact, in the direction of material flow and so there are no problems of air leakage across the device, as there are with conventional feeders of this type.
A rotary valve or screw may be used in this situation to guarantee the feed of a steady flow of material into a pipeline. If a rotary valve or screw is to be employed, designs to cater for high pressure differentials do not have to be used. Erosive wear problems associated with abrasive materials are also significantly reduced with this type of system. The most usual configuration is to mount the rotary valve or screw inside the blow tank. A sketch of a screw feeder based on this twin blow tank principle is given in Figure 2.26.

8.4.2.2 Applications
In cases where there is a need for a high air supply pressure, either to convey a material in dense phase or over a long distance, and continuous operation is essential, such a twin blow tank system is ideal. Although these systems do require more headroom than rotary valves, screw feeders and many single blow tank systems, this need not be excessive. It clearly depends upon the material flow rate to be achieved, but if a reasonable cycling frequency between the two pressure tanks is employed, the capacity of the vessels can be quite small and a compact system can be obtained.

A particular application of these systems is for the direct injection of pulverized coal (DIPC) into boilers and furnaces. In the case of furnaces the material often has to be delivered against a pressure. This, of course, presents no problem since high air supply pressures can be utilized.

![Figure 2.26 Twin blow tank system with screw feeding.](image_url)
A general requirement of DIPC systems is that the material should be conveyed at a very uniform rate, and that it should also be capable of achieving a high turn-down ratio. An operating range of 10:1 on material flow rate is often requested in this respect. Blow tanks are capable of operating quite successfully over this range and so they are ideally suited to this type of application.

8.4.2.3 Alternative Blow Tank Arrangement

If headroom is restricted, particularly in the case of an existing system, which may require to be changed or up-rated, it is possible to design a series operating blow tank system such that only the lock hopper has to be located beneath the supply hopper. A typical arrangement, with a screw feeder incorporated is shown in Figure 2.27.

In this case the conveying blow tank is positioned alongside the lock hopper and the transfer has to be achieved by pneumatically conveying the material between the two, instead of using gravity. The driving force for this particular development was the possibility of replacing screw pump feeding systems with such blow tanks. The lock hopper fits into the existing space beneath the hopper, vacated by the screw pump, and the blow tank is placed alongside. This requires the material in the lock hopper to be conveyed to the blow tank, but it does allow continuous operation.

Figure 2.27 Sketch of side-by-side arrangement of twin blow tanks in series.
8.5 Blow Tank Control

With rotary valves and screw feeders, material flow rate can be controlled, over a limited range, simply by varying the drive speed. Blow tanks, as it has already been mentioned, have no moving parts, and yet turn-down ratios of 10:1 can be achieved quite successfully.

8.5.1 Air Proportioning

Control of a blow tank is achieved by proportioning the total air supply between that which is directed to the blow tank and that which goes directly to the start of the conveying line. The total air supply is used to convey the material through the pipeline.

8.5.1.1 Blow Tank Air

The air directed to the blow tank is used to pressurize the blow tank. This air supply may also aerate or fluidize the material, depending upon the bulk characteristics of the material. The blow tank air discharges the material from the blow tank into the conveying line. The solids loading ratio of the material in the blow tank discharge line can be very high, and hence there is a pressure drop associated with this feeding. This is why supplementary air is necessary, unless the conveying line is short and high pressure air is available.

8.5.1.2 Supplementary Air

The supplementary air passes directly to the start of the conveying line at the blow tank discharge point. The supplementary air effectively dilutes the flow of material for conveying through the pipeline. It is essential that the correct solids loading ratio is achieved at this point in order to match the capability of the air mover in terms of pressure available.

If the solids loading ratio is too low, for example, the pressure drop over the conveying line will be low and the pipeline will be under-utilized. If, on the other hand, the solids loading ratio is too high, the pressure drop required to convey the material through the pipeline may exceed the capability of the air mover, and the pipeline will probably block.

8.5.2 Discharge Rate Control

To show how the proportion of air that is used to fluidize the material in the blow tank can influence the discharge rate, a graph of material flow rate against total air mass flow rate has been drawn, and data in terms of the ratio of fluidizing air to total air mass flow rate has been plotted. The resulting family of curves is shown in Figure 2.28.

This graph shows how the total air supply from the compressor should be divided between the blow tank for fluidizing the material, and the supplementary air line for conveying the material. Provision, therefore, must be made for this control facility on the plant, and this can be clearly identified as a point to observe during the commissioning of a plant.
Figure 2.28 Typical blow tank discharge characteristics.

Figure 2.28 was derived from the conveying of cement through a 330 ft long pipeline from a top discharge blow tank having a fluidizing membrane. Both the discharge pipe and the pipeline were two inch nominal bore and contained seventeen 90° bends. The 100% line represents the conveying limit for the blow tank, and would represent the only control available in a blow tank without supplementary air.

8.5.2.1 Material Influences

It is well known that different materials can have totally different conveying characteristics when conveyed through exactly the same pipeline. The same also applies in terms of different materials with respect to their blow tank discharge characteristics. These characteristics will also differ with blow tank type, in particular, top and bottom discharge configurations. If a higher discharge rate is required for a blow tank, an improvement in the aeration of the material might help. Otherwise a larger discharge pipe will be needed. The discharge pipe does not have to be the same diameter as the conveying pipeline.