bulk solids handling Volume 1, Number 1, February 1981

Rotary Valve Selection for Pneumatic Conveying Systems

Frank J. Gerchow, USA

Die Auswahl von Zellenschleusen für pneumatische Fördersysteme
Sélection des vannes à opercule tournant pour les systèmes de transfert pneumatique
Selección de válvulas giratorias para sistemas de transporte neumático
空気[illegible]システム用回転弁の選択
气压输送系统球形阀的选择
اختيار الصمام الدوار لأنظمة النقل التي تعمل بالهواء المضغوط

Die Auswahl von Zellenschleusen für pneumatische Fördersysteme

Die Auswahl einer Zellenschleuse für ein pneumatisches Fördersystem stellt eine besondere Kunst dar. Die richtige Auswahl wird zu einem System mit hohem Wirkungsgrad und langjähriger Betriebsbereitschaft führen.

Bei der Wahl der richtigen Zellenschleuse für ein bestimmtes System muß der Konstrukteur Faktoren wie Zellengröße, Ausführung, Anwendungsart und Kosten berücksichtigen. Dieser Artikel gibt dafür Richtlinien und Regeln, durch die die Aufgaben des Ingenieurs sehr erleichtert werden.

Sélection des vannes à opercule tournant pour les sytèmes de transfert pneumatique

Le choix d'une vanne à opercule tournant á utiliser dans un système de transfert pneumatique constitue tout un art. S'il est effectué correctlement, il en résulte un système total qui fonctionnera longtempts et sera d'une grande efficacité.

En choisissant la vanne à opercule tournant convenant à un système particulier, le créateur doit prendre en considération des facteurs tels que les dimensions de la vanne, son style, son application et son côut. Cet exposé offre une série de directives et de règles permettant de beaucoup simplifier la tâche de l'ingénieur.

Selección de válvulas giratorias para sistemas de transporte neumático

La selección de una válvula giratoria para su uso en un sistema de transporte neumático tiene algo de buen arte. La selección correcta dá como resultado final un sistema total con buen comportamiento a largo plazo y alto rendimiento.

Al elegir la válvula giratoria correcta para un sistema determinado, el proyectista tiene que considerar factores tales como el tamaño, el estilo, la applicación y el precio de la válvula.

Este trabajo ofrece guías y reglas orientativas para simplificar enormemente la tarea del ingeniero.

Summary

Selecting a rotary valve for use in a pneumatic conveying system is somewhat of a fine art. If undertaken properly, the end result will be a total system with a long-range operating performance and high efficiency.

In choosing the correct rotary valve for a particular system, the designer must consider such factors as valve size, style, application, and cost.

This paper offers guidelines and rules to greatly simplify the engineers' task.

Frank J. Gerchow, Product Sales Manager, Materials Handling, Sprout-Waldron Division, Koppers Company Inc., Muncy, PA 17756, USA

1. Introduction

Rotary valves frequently are called the heart of a pneumatic conveying system. Rightly so, for a system will not function unless the rotary valves in it perform properly.

Correct valve selection based primarily on size, style and intended use, and cost is therefore of considerable importance.

Rotary valves may function as feeders operating under a head of material and serving as the metering device, or they can be purely air locks, functioning as air seals only. Often these functions are combined when the valve meters the product into a pneumatic conveying system.

2. Basic Valve Types

There are two basic types of rotary valves. The most popular is the *drop-through* type (Fig. 1) with the inlet on top and

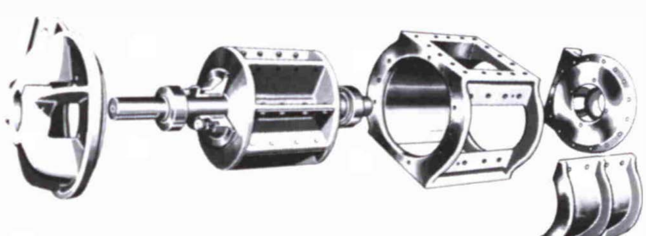


Fig. 1

outlet directly below on the bottom. The *blow-through* type, literally a valve in a pipe line, features the same top inlet as the first type, but is discharged through matching flanges on the end bells, allowing the conveying air to pick up material from the rotating rotor pockets.

A *side-inlet* style, a modification of the *drop-through*, features an off-center inlet that slopes 45° into the side of the valve to feed free-flowing granular materials. This unit meters product into the system from a head of material without breaking or shearing the product.

2.1 Rotor Types

The rotors can be either *open-end* where the blades are welded directly to the drive shaft or *closed-end* with a disc, or *shroud welded* to the ends of the blades and shafts to form enclosed pockets.

Open-end rotors are less expensive, but they have the disadvantages that:

— Abrasive materials cause wear of the end bells on the valve casing and product can become trapped between ends of the blades and housing.

— *Open-end* rotors are not as strong as the *closed-end* type.

When the rotor has closed ends, it is possible to have either *closed* or *open-bottom shrouds* on the casing. Open bottoms are more popular because any product that gets into this area has sufficient clearance to drop out by gravity. With the *closed-bottom shroud,* it is desirable to air-purge the ends to ensure that no product gets into the void. *Open bottoms* can be air purged from the conveying line, but with the *closed bottom* the air-purge source usually has to be an auxiliary piece of equipment.

When a *closed-rotor* is applied in a negative pressure system (with vacuum on top of the valve and ambient conditions on the bottom) a natural air purge can minimize wear in the shroud area. A shaft seal can then be omitted, and purge plugs in the casing end plates can be opened to the atmosphere so that the leakage through the valve is atmospheric air; this air washes the shroud area and eliminates wear. If the valve casing ends were not open, leakage air would be drawn up from the conveying line transporting product and dust with it, causing wear in the shroud area.

It is sometimes desirable with valves having a closed-bottom shroud to use a shroud packing or a piston-ring seal, whose main purpose is to miniminze leakage past the shroud area.

2.2 Rotor Pocket Configurations

There are four rotor pocket styles to accommodate the different types of product handled in a pneumatic system. With reference to Fig. 2 these are:

— Type 1 has deep pockets and maximum volumetric displacement.

— Type 2 is similar to Type 1, but has adjustable and replaceable tips made of various materials.

— Type 3 with a shallow pocket and about half the volume displacement of Type 1, is primarily a feeder which allows the valve to turn faster to deliver a relatively small amount of product. Type 3 has also been successful with materials that stick to the rotor pockets. Sometimes a counter-weighted scraper is placed in the rotor the assure complete cleanout.

— Type 4 rotors are utilized with very fine particle sizes that tend to bridge easily and fail to flow more granular products. Obviously, they restrict the amount of materials fed into the system, while presenting a fairly large area at the inlet to receive product from the bin above.

3. Valve Construction

Rotary valves can be either cast of fabricated. The most common materials of construction are cast iron, carbon or stainless steel and aluminium.

A most important feature in any rotary valve is an inspection panel in the casing, located opposite the motor. This permits the operator to remove material that may have caused jamming, to adjust rotor tips, or to determine the valve's clearances and wear.

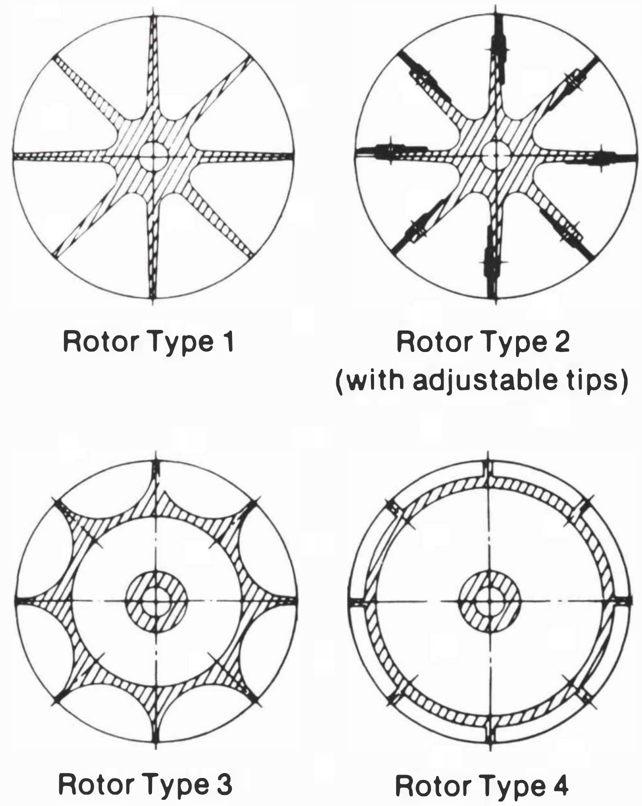


Fig. 2

In abrasive systems, the rotor shrouds are usually stellited, with replaceable rotor tips of cast Ni-hard steel. In extreme cases, the entire bore of the valve housing can be stellited, although a chrome-plated bore is often used. Aluminium construction may be used where the product is non-abrasive.

The bearings for a rotary valve should be mounted outboard, with a good stuffing box or mechanical shaft seal between the inside of the valve and the bearings. This places the bearings as far away from the product zone as possible to eliminate the product from getting into the bearings and causing premature failure. Conversely, it keeps lubricants out of the product.

A minimum of three to four rings of packing-gland shaft seal, among the best for maintenance purposes, should be installed. If the product is abrasive or difficult to seal, then a lantern ring can be added to ensure inward leakage of air, thus preventing product from coming in contact with the packing.

4. Special Designs

Several special duty designs are available to accommodate unusual operating conditions. For abrasive products, such as cement, a fabricated valve is made from abrasion-resistant steel, which has completely enclosed shroud ends, and no inspection panel.

Side-inlet valves are primarily feeding devices for free-flowing granular materials. Because of the side inlet, shearing of product between the rotor and the casing is eliminated.

Blow-through valves have the air sucked or blown through the inlet and discharge connections at the end bells of the valve, beneath the shaft bearings. The rotor is of the open-end type to allow for passage of air along its axis. The valves are fairly long in relation to the rotor diameter, which makes the rotor act as a flexible beam. Therefore the maximum pressure differential across the valve is limited to about 10 lb/in². Such blow-through models are not recommended for abrasive materials, and are limited to materials that tend to lubricate, such as wheat flour. One advantage is that they feed material into the air stream. The product is literally blown out of the rotor pockets by the conveying medium, which naturally prevents materials from sticking in the pockets (Fig. 3).

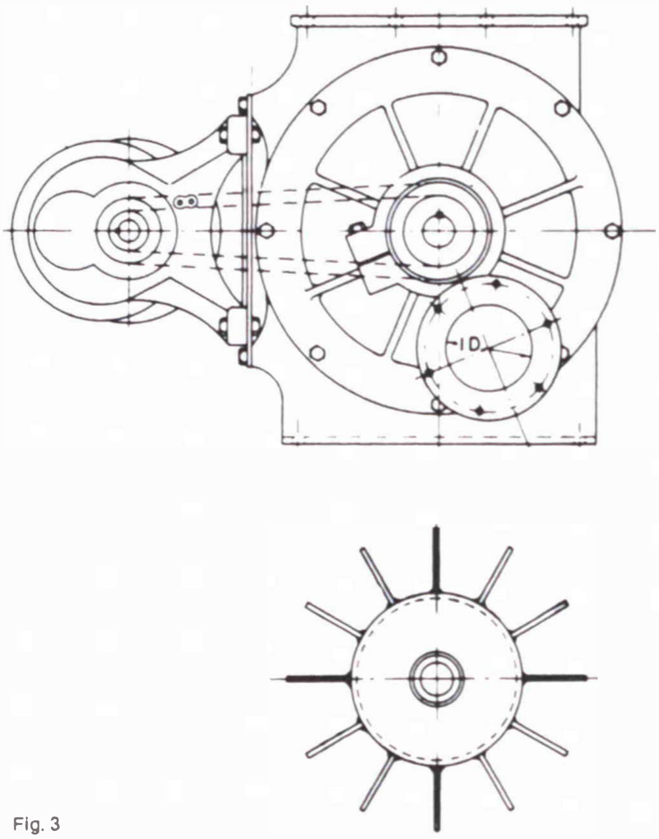
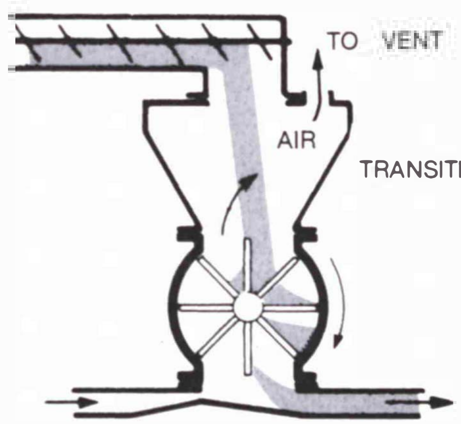


Fig. 3



POSITIVE PRESSURE PNEUMATIC CONVEYOR

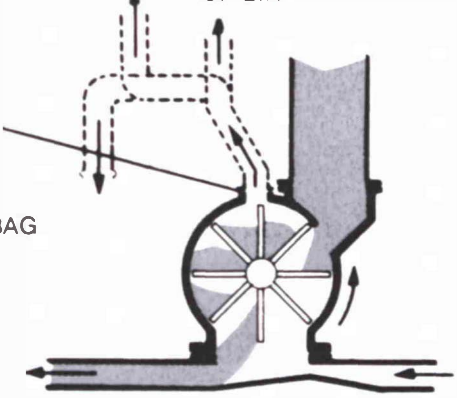


Fig. 4 VENTING SIDE INLET VALVE

Rotary valves used as air seals sometimes can also operate under a head of material as metering devices. However, if the pressure differential is such that the pressure is greater on the bottom side of the valve, a leak from the discharge side to the inlet side occurs, due to clearances and normal expansion of air or gas.

When the valve is at the inlet of the positive pressure system, the leaked air, plus the displaced air out of the rotor pockets, must be vented and perhaps filtered, if the product is dusty. This could involve an elaborate dust collecting system, or running a vent line to the top of the storage tank, if the tank is properly vented or filtered. Some valves have built-in vents to take care of leakage air, but if they are not so equipped, special inlet-vent hoppers are required (Fig. 4). A baffle is needed to minimize the amount of material in the vent area only when the valve also acts as a feeder under a head of product.

Blow back air reduces the volumetric efficiency of the valve by slowing up pocket filling, and if the product tends to aerate or fluidize, the blow back air will naturally cause aeration, thereby reducing the bulk density.

Sometimes however, it is not necessary to vent the blow back air. When the air lock operates under a head product that can be aerated, the blow back air aids the flow of product out of the bin or hopper above the valve. With products that do not fluidize, or where the blow back air cannot percolate up through the product, an air bubble is usually formed, which stops flow of product out of the hopper in cases where the air is not vented.

5. Sizing the Proper Valve

A pure gravity-type feeder, with no pressure differential across the rotary valve, is simple to size. The desired displacement is given in ft³/h with a 10 to 15% factor reserve for discrepancies in bulk densities, etc. Usually, such valves need no venting because the only air moved is that being expelled from the rotor pockets as the bulk material flows in.

To size a valve operating under poor pocket-filling and product aeration conditions, it is best to select one based on 50% of its maximum displacement, at normal air lock speeds or standard rpm. This is recommended whether the valve is to be an air lock or a combination of air lock and feeder. Once the size is selected on this basis, the valve's speed as a feeder can be determined from displacement figures, which yield the minimum speed at which the valve must run (Table 1).

Table 1:
Typical data for sizing rotary valves

	Rotor Displacement, ft³/rev			
Rotor Size	Type 1	Type 2	Type 3	Type 4
4 x 3	0.0128	0.0119	0.0065	0.003
6 x 4	0.039	0.030	0.020	0.010
8 x 6	0.125	0.114	0.063	0.032
10 x 8	0.27	0.21	0.13	0.07
14 x 10	0.700	0.680	0.310	0.155
16 x 10	1.300	1.225	0.650	0.325
20 x 18	2.700	2.500	1.150	0.575
24 x 22	4.6	4.5	2.3	1.15
30 x 26	8.55	8.3	4.2	2.1

Motor and drive are also selected on this basis. After start-up, the valve's speed can be increased, if necessary, by sheave or sprocket change.

If experience exists with the flow of product under similar conditions, the apparent density of the material passing through the valve can of course be determined. The density is the equal to the weight of the product delivered per time unit, divided by the volume displaced by the rotary valve in the same unit of time. The valve thus serves as a feeding or metering device at the inlet of a positive pressure system.

If the valve serves as an air lock at the outlet of a negative pressure system, it is not necessary to vent the blow back air, because the vacuum at the valve inlet automatically takes care of leakage air through the valve. If however, the valve is being used as a metering device at the outlet of the vacuum system, the venting of leakage air to the inlet or top of the vacuum vessel may be needed to ensure product flow out of the vessel.

The sizing of valves at outlets of vacuum systems is performed as described above. When the lower pressure is on the outlet or bottom of the valve, inlet in the case of a negative system, or at the outlet of a pressure system, the flow of leakage air is down through the valve in the direction of material flow. This means that there is no inlet blow back air to contend with. In such cases, the volumetric efficency of the valve is greatly improved, approaching that of a gravity feeder. The valves can be sized similarly to the feeders, although if an additional safety factor is desired, the valve should be sized using the 50% capacity figure.

Air lock speeds or standard speeds for rotary valves are those that give maximum displacement and allow for good product flow through the valve by allowing sufficient exposure time of the pocket to the product for good filling. Speeds normally range between 30 to 45 rpm., depending on the valve size.The larger the valve, the slower the speed.