Comparison of blower types used in pneumatic conveying systems

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At the heart of every pneumatic conveying system is the air-moving device or blower. This article compares two basic blowers used in dilute-phase pneumatic conveying systems: the positive displacement blower and the fan-type turbo blower. By applying a few basic principles of pneumatic conveying and analyzing the relationship between the characteristics of each blower and the conveying line, some general guidelines for selecting the proper blower for an application can be established.

Both positive displacement blowers and single-stage or multi-stage fan-type turbo blowers must perform two basic functions: (1) they must develop a pressure difference within the conveying system that is equal to the total resistance of the complete system in order to convey material; and (2) they must displace a sufficient volume of air to facilitate material acceleration and to maintain the required air velocities to convey material. These functions will hold true regardless of whether the system is vacuum only, combination vacuum/pressure, or pressure only.

Air flows through a pipe or conveying line because of a decrease in absolute pressure in the direction of flow. Since air is a compressible fluid, any decrease in pressure results in a decrease in the density of the air. Even though the mass rate of airflow is constant, the volumetric rate and the air velocity through a constant cross-section of pipe increases in the direction of flow.

At any given rotational speed, a specific blower can theoretically develop a unique compression ratio for each flow rate it is capable of handling. This is the ratio of the absolute discharge pressure to the absolute inlet pressure. There are practical obtainable limitations to compression ratios, maximum pressures, and maximum vacuums. The usable compression ratios do not differ appreciably between positive displacement blowers and fan-type turbo blowers designed for pneumatic conveying.

Characteristics of positive displacement blowers
The positive displacement blower is a rotary lobe type, fixed displacement, air-moving device. The inlet volume, or airflow, at any one rotational speed is fixed or theoretically constant and depends solely on the size or displacement of the unit. The compres...
sion ratio, or pressure developed, is a function of the system resistance. The positive displacement blower is applicable over a range of pressures, but at a relatively constant airflow.

Figure 1 shows the characteristics for a positive displacement blower. As the pressure across the blower rises, the air volume will theoretically remain constant, but in actual practice will decrease slightly. This decrease in volume with the increase in pressure is caused by the leakage of discharge-side, high-pressure air back to the inlet side of the blower by way of mechanical clearances between the rotating parts. The mechanical clearances increase as a result of component wear when proper filtering is not present, thereby reducing the compression ratio and the volumetric efficiency of the positive displacement pump.

Positive displacement blowers use relatively high torque, have low rpm, and require horsepower comparable to that of fan-type turbo blowers for development of usable vacuum and pressure. The horsepower requirement varies directly with the pressure requirement. As the pressure increases, so does the horsepower. In other words, horsepower increases as resistance, or material, is introduced into the system.

Advantages of positive displacement blowers

• They have slightly higher maximum attainable compression ratios.

• They are generally constructed of high quality materials and are machined to close tolerances, which results in good performance.

• There are more sizes of positive displacement blowers available within the range of flows and compression ratios required for pneumatic conveying than there are for fan-type turbo blowers.

• With proper maintenance and very efficient filtering of air entering the blower inlet, a positive displacement unit will provide good service and longevity.

• They are considered ideal for pressure-only applications.

Disadvantages of positive displacement blowers

• Much of the advantage of slightly higher maximum attainable compression ratios is lost when protective relief devices on the positive displacement pump are set at vacuum and pressure readings below the maximum attainable levels.

• The remaining pressure advantage is partly lost through additional air losses caused by the air-filtering equipment that is required ahead of the blower, or is lost when increased air velocities increase product degradation.

• Relief valves are required to prevent the blower from overloading and seizing or binding.

• These units are susceptible to damage and wear from foreign dust material and usually require good air-filtering equipment.

• The characteristics of these blowers make it difficult to compensate for conveying various materials. If not compensated for lower air velocity requirements, the excess velocity will cause increased product degradation.

• Silencing equipment is generally required due to the high noise level generated by the blower.

Characteristics of fan-type turbo blowers

The fan-type turbo blower is a centrifugal, theoretically variable displacement, air-moving device. The inlet volume, or airflow, depends on the impeller design and the system resistances. The compression ratio, or pressure developed, is a function of the tip speed of the impeller and the number of stages. Fan-type turbo blowers are designed, or specified, based on the line size of the system to be used and the airflow and pressure requirements.

Figure 2 shows that the fan-type turbo blower is applicable over a range of air volumes while maintaining relatively the same pressure. These units use relatively low torque, have high rpm, and require horsepower comparable to that of positive displacement blowers for development of usable vacuum and pressure. The horsepower requirement varies with airflow, rather than pressure. The horsepower decreases as resistance, or material, is introduced into the system.

Advantages of fan-type turbo blowers

• They allow the air volume to be adjusted to optimize conveying capacities for handling a variety of materials over different piping systems. This is done by maintaining approximately the same compression ratio at different airflow rates.

• They generate a continuous, rather than pulsating, flow of air and usually do not require silencing equipment.

• Units with reserve horsepower can sustain higher conveying rates when there are leaks in the piping system.

• They are less susceptible to foreign material damage and require no air-filtering devices other than a cyclone for the incoming air.

• The horsepower requirements of these units decrease as the conveying rate increases.

Disadvantages of fan-type turbo blowers

• They generally require more horsepower than positive displacement blowers to reach the same pressure and airflow ratings.

• They require dampers, or air regulators, to limit the horsepower demand when resistances decrease sufficiently to allow excessive airflow into the system.
They are less capable of blowing out a plugged conveying line than positive displacement blowers.

They use a relatively high rotational speed, which requires both static and dynamic balance.

Conveying line characteristics
The characteristics of the conveying line can be represented graphically by various inlet air volume flows and various product rates (Fig. 3).

To determine the actual operating point of a specific system with either type of blower, it is necessary to first deduct all losses other than those incurred in the actual conveying line. Next, convert the blower performance curve to the flow rate used in determining the conveying line characteristics. The point of intersection between the blower performance curve and the maximum capacity conveying line curve will be the optimum conveying point. This will also indicate that maximum capacity can be obtained with the minimum air required without plugging the lines.

Table I Air velocity comparisons

<table>
<thead>
<tr>
<th>Positive displacement blower (2 to 1 compression ratio)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (&quot;Hg)</td>
<td>0</td>
<td>-3.75</td>
<td>-7.5</td>
<td>15</td>
<td>7.5</td>
<td>0</td>
</tr>
<tr>
<td>Air velocity (ft/min)</td>
<td>6,000</td>
<td>7,000</td>
<td>8,000</td>
<td>4,000</td>
<td>5,000</td>
<td>6,000</td>
</tr>
<tr>
<td>Air volume (ft³/min)</td>
<td>1,176</td>
<td>1,372</td>
<td>1,570</td>
<td>785</td>
<td>980</td>
<td>1,176</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fan-type turbo blower (1.7 to 1 compression ratio)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (&quot;Hg)</td>
<td>0</td>
<td>-2.8</td>
<td>-5.6</td>
<td>11.5</td>
<td>5.75</td>
<td>0</td>
</tr>
<tr>
<td>Air velocity (ft/min)</td>
<td>5,530</td>
<td>6,165</td>
<td>6,800</td>
<td>4,000</td>
<td>4,665</td>
<td>5,530</td>
</tr>
<tr>
<td>Air volume (ft³/min)</td>
<td>1,083</td>
<td>1,208</td>
<td>1,334</td>
<td>784</td>
<td>914</td>
<td>1,083</td>
</tr>
</tbody>
</table>

All materials have their own unique minimum required pickup velocity, based on factors such as size, shape, bulk density, friction, and minimum conveying velocity. When designing a system to handle a multitude of products, you must consider both the material requiring the highest air velocity as well as the material requiring the lowest air velocity. The highest air velocity requirement will be the design or sizing criteria for the system.

When a positive displacement blower is the source of air pressure, a problem arises when the conveyor is used for the material requiring the lower air velocity. If some means is not provided to reduce the air volume, the blower will discharge too much air for the lower velocity material, causing excess material velocities within the system and more product degradation. The accepted method of reducing the airflow involves reducing the speed of the positive displacement blower, since the unit handles a specific air volume based on the rotational speed. However, in some cases, such as with an electric-powered unit, this is not very practical. You cannot easily restrict the air inlet on a positive displacement blower to reduce the air volume.

When a fan-type turbo blower is the source of air pressure, the inlet air volume can be easily restricted, either by the addition of more material or by restricting the air inlet at the intake nozzle. The airflow or velocity is reduced accordingly without having to reduce the fan speed, while the blower maintains relatively the same vacuum and pressure capability.

In Fig. 4, air enters the intake nozzle at atmospheric conditions at point A. As the air moves toward the blower, it becomes less dense as the pressure decreases, or vacuum increases. As the air becomes less dense, the velocity increases. The blower then compresses the air and it is discharged from the blower in its most compressed or dense state at point D. This is also the point of low-
est velocity within this system and the point where the material must be accelerated (the most critical point). As the air moves toward the end of the discharge pipe, it again becomes less dense, or expands, until it reaches atmospheric conditions at the outlet of the system (point F).

Table I provides air velocity comparisons for the positive displacement blower and the fan-type turbo blower. Compare point D for both systems, assuming a 6-inch diameter pipeline. The positive displacement blower operates with a 2 to 1 compression ratio, of which half is used for suction and half is used for pressure. The fan-type turbo blower operates at a 1.7 to 1 compression ratio, using a pickup velocity requirement of 4,000 ft/min.

Although the positive displacement blower has the capability of 2 to 1 compression, most manufacturers recommend that this be reduced to about 1.8 to 1 to reduce wear and increase the operating life of the unit. As shown in the compression ratio chart for the positive displacement blower (Table I), the pressure has increased from point A to point D, but there is also a higher air velocity in the system, which can cause product damage and degradation.

Conclusion

Each pneumatic system should theoretically be designed around a piping layout, with special emphasis on the material being conveyed, since different materials require different criteria. For instance, because of its shape, corn requires much less airflow or velocity than soybeans. But suppose you need to move both materials using the same conveyor. In a system designed to move soybeans using a positive displacement blower with constant airflow, there will be too much air to handle the corn—regardless of the pressure used—without causing product damage and degradation. However, a system using a fan-type turbo blower can adjust the airflow to fit the corn’s conveying requirements. Provided all other characteristics are acceptable, this may be the best blower choice for this application.

Engineers should evaluate a pneumatic system on the basis of the material they will be moving, keeping in mind that some materials require less airflow or velocity than others. The characteristics, advantages, and disadvantages of the two types of blowers should then be considered, to determine if they fit the material’s conveying requirements.

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