Rotary valve return on investment: Doing the math

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Should you buy a low-cost, replaceable rotary valve or a high-cost, heavier-duty version that can be rebuilt? Calculating a rotary valve's return on investment is a good place to start. After describing available rotary valves, this article explains how running a series of cost calculations can help you choose the most cost-efficient valve for your application.

As part of the bulk solids handling industry, you know that your company will experience significant savings in the long run by investing in high-quality equipment from the start. However, when it comes time to purchase a new rotary valve, it can still be difficult to justify spending three times as much for a rotary valve that will do the same job as a less-expensive valve.

Whether your money is better spent on a low-cost, replaceable rotary valve or a higher-cost, rebuildable valve is a decision only you can make based on your application and budget. However, when it comes to making your choice, you don't have to take a leap of faith; you just have to do the math. Before we discuss the cost calculations, let's take a look at rotary valves, how they work, how the valves can be replaced or rebuilt, the differences between standard- and severe-duty valves and non-adjustable and adjustable tolerances, and valve service life.

Some rotary valve basics

A rotary valve (sometimes called a *rotary airlock valve* or *rotary feeder*), as shown in Figure 1a, controls the flow of a dry, free-flowing bulk material between atmospheres that are typically at different pressures. Always functioning as a gravity-flow device, the valve can operate as an airlock, a feeder, or a combination feeder-airlock in a vacuum or pressure conveying system.

Components in a typical rotary valve, as shown in Figure 1b, include a housing and endplates (which form a cylindrical cavity with an inlet and outlet) and a rotor with blades (also called *vanes*) mounted on a rotor shaft. The rotor is supported by bearings, and a motor and drive turn the rotor shaft, causing the rotor to rotate inside the housing. The housing can have a drop-through, side-entry, or blow-through design, and the inlet and outlet can be round, square, or rectangular. The rotor can have open or closed ends (a closed-end rotor has plates at either end of the housing) and 6, 8, 10, or 12 blades. The blades can have adjustable tips and be square, beveled, or inlaid. The rotor-tip-to-housing clearance (called *tolerance*) can be adjusted to suit your material and operating requirements.

In operation, material enters the inlet and drops into the space between adjacent blades (called a *rotor pocket*). As the blades rotate, the material is carried in the pocket toward the outlet. Shaft seals prevent air (or other gases) and material from leaking into or out of the valve. [***Editor's note:*** Find more information on rotary valves in Paul E. Solt's July 1994 "Pneumatic points to ponder..." column, *Powder and Bulk Engineering,* pages 59-67.]

Low-cost, replaceable versus high-cost, rebuildable

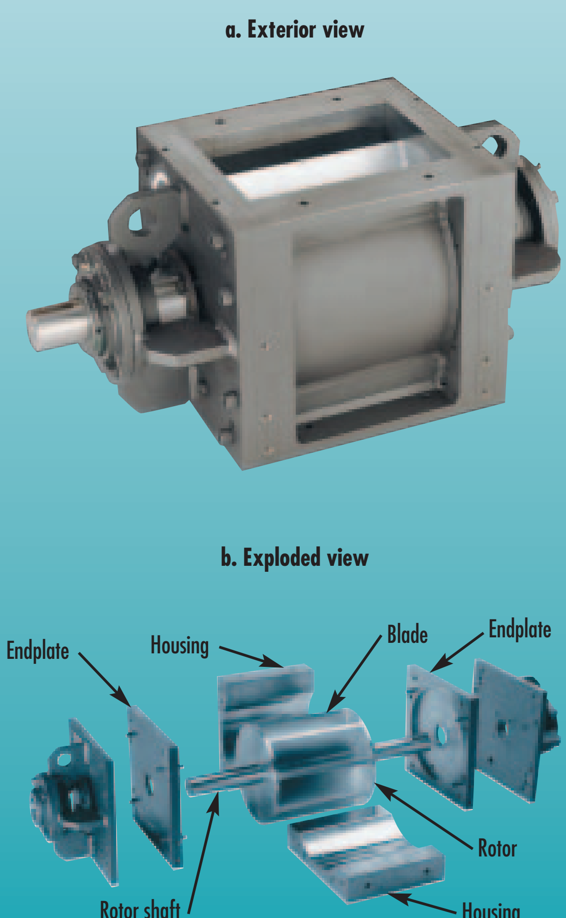
Even though all rotary valves perform the same basic function, many different types are available on the market today. They can be broadly described as ranging from low-cost, replaceable valves to high-cost, rebuildable valves.

Low-cost, replaceable rotary valve. A low-cost rotary valve can be cast or fabricated, and its housing and components are typically made of iron. Because of the valve's low initial cost, it's typically considered replaceable. This valve is often considered a standard-duty valve for handling nonabrasive or noncaustic materials because its housing and components have no chrome plating.

High-cost, rebuildable rotary valve. A high-cost rotary valve can be cast or fabricated and its housing and components are typically made of an alloy such as stainless steel. A fabricated valve has a modular design in which its housing and internal components are bolted together, allowing easy access for maintenance. This valve typically has a thicker housing wall than a low-cost rotary valve and can be rebuilt multiple times. It's often considered a severe-duty valve because its housing and components are generally constructed of a work-hardened alloy with chrome plating to resist wear from abrasive or caustic materials.

Figure 1

Typical rotary valve (with drop-through housing)



How valves are replaced or rebuilt

When a rotary valve wears out or breaks down, you can either replace or rebuild it.

Replacing a valve. Replacing the valve entails ordering a new valve from the supplier, shutting down the production line, removing the worn valve from the line, and installing the new one in its place. This can lead to excessive downtime and increase your production costs, depending on how long it takes to get the new valve, how much you must pay to have it delivered, and how long it takes to install it. You can reduce downtime losses by keeping a spare valve onsite.

Rebuilding a valve. You can either rebuild a valve offline or inline, depending on the valve. To rebuild a valve offline, you must remove the valve from the production line and either send it to the supplier for rebuilding or rebuild it onsite. A cast rebuildable valve typically must be rebuilt offline because if the valve isn't removed the cast housing makes it difficult to access the valve's internal components. The cast valve typically is sent to the supplier for rebuilding, because very few plants have the equipment, space, or skilled operators to rebuild the valve onsite.

To rebuild a valve inline, you leave the valve connected to the production line and stop the material flow or divert it into another line, then remove the valve's worn internal components through an access plate in the valve housing and reinstall new components. A fabricated, rebuildable rotary valve typically can be rebuilt inline because its modular design allows you to easily access, remove, and replace the internal components.

Rebuilding a rotary valve can be cost-effective, depending on how long it takes you or the supplier to rebuild the valve, how much you must pay to have the rebuilt valve or replacement parts delivered, and how much your downtime will cost. To reduce downtime, you can keep replacement parts or a spare valve onsite.

Theoretically, every rotary valve — even a low-cost cast-iron valve — is rebuildable. But the practical question is whether it makes economic sense to rebuild a low-cost valve. Often, by the time you rebuild the valve and pay for shipping, parts, labor, and downtime, you can run up a bill that's as much as or more than the valve's initial cost.

Standard duty versus severe duty

There's no industry standard as to what qualifies a rotary valve as standard duty or severe duty, because each supplier has its own definition. However, most base this distinction on a valve's ability to handle certain materials, the valve's service life, and whether the valve is replaceable or rebuildable. For instance, a standard-duty rotary valve is generally constructed of cast-iron with no hard-plate coating. This valve is often replaceable and is typically used with materials such as paper, sawdust, borax, salt cake, chalk, gypsum, lactose, soap, sulfur, and agricultural products.

A severe-duty rotary valve is generally constructed of a special alloy, such as 500 Brinell alloy, and has a hard plating, such as industrial chrome. This valve is often rebuildable and is typically used with materials such as fly ash, bottom ash, lime, sand, cement, fossilized coral, hot sludge, diatomaceous earth, recycled glass, petroleum coke, and alumina ore. Generally, it takes more time to rebuild a severe-duty valve than a standard-duty valve because the hard-plate coating must be removed before the valve can be machined, and the coating must be reapplied before the valve can be used.

If you purchase a standard-duty rotary valve and later discover that you need a severe-duty valve, you don't necessarily have to buy a new valve. Often, you can buy severe-duty replacement parts and install them in the standard-duty housing. The severe-duty parts are identical dimensionally to the standard-duty parts, but are constructed of a harder material and are chrome plated.

Non-adjustable versus adjustable tolerance

Tolerance is the distance (or gap) between the rotary valve's housing and rotor blade tips. A supplier determines a valve's tolerance based on the material being conveyed, the valve's operating temperature, and the valve construction material's thermal expansion (a material's fractional change in length or volume per unit change in temperature). A correctly established tolerance ensures efficient production line operation and consistent material conveying. Too large a gap allows air and material to pass through, causing excess waste and a pressure drop across the line. Too small a gap allows material to become trapped between the housing and rotor tips, hastening valve wear and possibly binding the rotor.

A valve can have a preset non-adjustable tolerance or an adjustable tolerance. A preset tolerance is established by a supplier, and you must send the valve back to the supplier to adjust the tolerance. A valve with an adjustable tolerance uses either extendable tips or a spring-tensioning device. Extendable tips fit on the ends of the rotor blade tips, and you manually lengthen or shorten them to adjust the tolerance. A spring-tension device uses bolts and springs to move a section of the valve's housing toward or away from the rotor blade tips, and you manually adjust the tolerance by turning the bolts.

A valve with a preset tolerance is more maintenance-friendly and accurate than a valve with extendable tips or a spring-tension device. Manually establishing a valve's tolerance after it's been assembled is time-consuming, difficult, and sometimes inaccurate because you must use feeler gauges (thin, stackable metal strips of known thickness) to verify the distance between the rotary blade tips and housing. This can be a challenge because naturally occurring wear over a valve's operating life isn't uniform. Material can load up on one side and wear the housing unevenly, or a rock or tramp iron can score the housing, causing the gap to vary from end to end.

Valve service life

You really don't know exactly how long a rotary valve is going to last in an application until it wears out. However, you can make a reasonable prediction for a valve's durability and service life based on the valve's construction material and your bulk material's characteristics. In essence, you need to determine how the valve's construction material will interact with your bulk material. For example, the harder the valve's construction material, the better it will handle abrasive materials. However, even a valve with the highest-quality construction material will wear at a greater rate when handling abrasive or acidic materials than when handling nonabrasive or neutral-pH materials.

For help choosing a rotary valve that's going to last the longest in your application, ask the valve supplier for case histories and performance data on the model you're considering. This will give you an idea of the valve's past performance and how frequently you may need to replace or rebuild the valve.

Calculating ROI

Choosing the most cost-efficient rotary valve for your application finally comes down to doing the math — that is, calculating your return on investment (ROI). This is the only way to determine whether a low-cost, replaceable valve that costs less initially or a high-cost, rebuildable valve is really a better deal in the long run. To calculate ROI for the valves you're considering, you'll need to know their initial costs, their annual replacement or rebuilding costs, and their estimated service lives. Make your ROI analysis by using the following calculations. Calculation 1 covers any replaceable rotary valve, calculation 2 covers a rebuildable cast valve, and calculation 3 covers a rebuildable fabricated valve.

Calculation 1. To calculate the annual cost to replace any low- or high-cost rotary valve, use this formula:

[(Valve's initial cost) + (Shipping costs from the supplier) + (Installation costs, including labor) + (Downtime costs, including lost product)] × (Number of replacement valves in 1 year) = Annual cost of replacing a valve

Calculation 2. To calculate the cost to rebuild a low- or high-cost cast rotary valve offline, start with this formula:

(Shipping costs to and from the rebuild location) + (Rebuild costs, including parts and labor) + (Downtime costs, including lost product) = Cost to rebuild the cast valve offline

Then, calculate the annual cost of rebuilding this valve offline:

(Cost to rebuild the valve offline) × (Number of times the valve is rebuilt in 1 year) = Annual cost of rebuilding the cast valve offline

Next, calculate the valve's cost for 1 year:

(Valve's initial cost) + (Annual cost of rebuilding the valve offline) = Cost of the cast valve for 1 year

Next, calculate the total cost of using this valve over its service life:

(Valve's initial cost) + (Cost of rebuilding the valve offline over its estimated service life) = Total cost of the cast valve

Finally, calculate the average cost per year of using the cast rotary valve:

(Cast valve's total cost) / (Number of years the valve is used, or the supplier's estimate for the number of years the valve will be used) = Average cost per year of using the low- or high-cost cast valve

Note: A cast rotary valve must be replaced after several rebuilds; this cost isn't factored into this equation.

Calculation 3. To calculate the cost to rebuild a high-cost fabricated rotary valve inline, start with this formula:

(Replacement parts' shipping costs) + (Rebuild costs, including parts and labor) + (Downtime costs, including lost product) = Cost to rebuild the fabricated valve inline

Then, calculate the annual cost of rebuilding the fabricated valve inline:

(Cost to rebuild the valve inline) × (Number of times the valve is rebuilt in 1 year) = Annual cost of rebuilding the fabricated valve inline

Next, calculate the valve's cost for 1 year:

(Valve's initial cost) + (Annual cost of rebuilding the valve inline) = Cost of the fabricated valve for 1 year

Next, calculate the total cost of using the fabricated valve over its service life:

(Valve's initial cost) + (Cost of rebuilding the valve inline over its estimated service life) = Total cost of the fabricated valve

Finally, calculate the average cost per year of using the fabricated valve:

(Fabricated valve's total cost) / (Number of years the valve is used, or the supplier's estimate for the number of years the valve will be used) = Average cost per year of using the high-cost fabricated valve

Note: If you specify the fabricated valve correctly, you shouldn't have to rebuild it within the first year of operation.

Putting it all together. To determine which rotary valve offers the best ROI over its service life, compare the total costs of the valves, as determined by calculations 1,2, and 3. The results may surprise you. Although you may pay more upfront for a high-cost fabricated valve that can be rebuilt inline, its rebuilding costs are lower, and, after a certain time, its total cost will equal that of a low-cost cast valve. At that time, you have established a return on your investment.

A final note: When doing your research, ask the rotary valve supplier what kinds of qualifications and tools are needed to replace or rebuild a valve. Some valves require a specialist, while others require only an operator who can use an Allen or crescent wrench. **PBE**

For further reading

Find more information on rotary valves in articles listed under "Valves" and "Pneumatic conveying" in *Powder and Bulk Engineering*'s comprehensive index to articles at www.powderbulk.com and in this issue.

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