Preventing wear and abrasion on slide gates and diverter valves

Kevin R. Peterson and Logan T. Cameron Vortex

Worldwide, companies are handling thousands of dry bulk solid materials, all with vastly different characteristics. Many of those materials also possess abrasive characteristics of varying complexities. To prolong service life and ensure superior performance of material handling components, equipping slide gates and diverters with application-specific features for handling abrasive materials becomes very important. This article discusses possible techniques that can help.

The terms wear and abrasion are often used interchangeably, but they aren't quite synonymous. *Abrasion* is a mechanical process in which coarse materials rub against the surface of another material. This creates *wear*, which is the degradation of surface material that occurs as a result of abrasion. Corrosion and oxidation also can cause wear. In these cases, a chemical reaction takes place between two incompatible or "combative" materials.

The physics of conveying abrasive materials

Whether one operates a gravity-flow or a dense- or dilute-phase pneumatic conveying process, the physics of dry bulk material movement will dramatically impact the degree of wear a system is subjected to. For this reason, it's necessary to assess which processes are more susceptible to material impact and carefully design the system to protect those areas.

Generally speaking, the highest degree of wear will likely occur in spots where the material flow pattern or air pressure are subjected to dramatic change or disruption, as shown in Figure 1. Such spots might include pneumatic conveying system elbows; areas where material flow changes direction, is diverted, converges, or suddenly halts; spots where there's an aspiration of displaced air; and many other system design variables.

Depending on application parameters, several techniques can be used to protect a system from rapid wear and abrasion. Options for pneumatic conveying and gravity-fed applications differ and are discussed separately in this article.

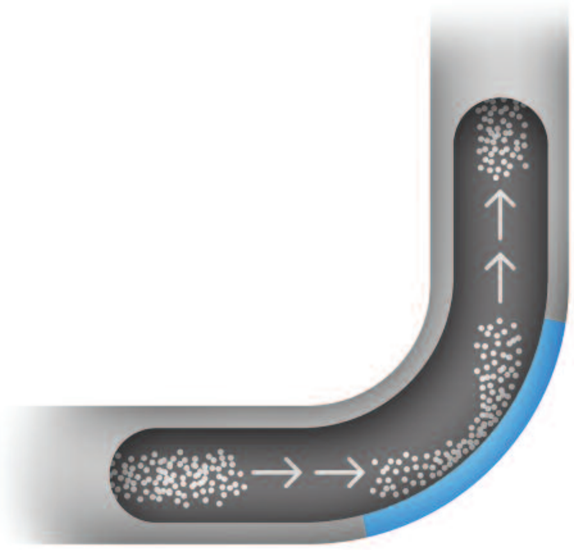
Pneumatic conveying applications

Valve construction. When pneumatically conveying moderately abrasive powders, pellets, and granules, constructing a diverter's material contact areas from Type 304 or 316L stainless steel will often provide appropriate abrasion resistance. To address extreme abrasion, a valve's inlet and outlet weldments can be constructed from schedule 10, 20, 40, or 80 pipe. In some instances, this option provides the dual benefit of increased abrasion resistance and a better match-up of components within the system's existing footprint. Materials of construction should be selected based on application parameters and the characteristics of the dry bulk solids being handled.

Seal protection. To decelerate wear to a valve's internal seals, the valve should have an unobstructed channel that shields all seals from blast abrasion as materials pass through. Such a design increases the seals' longevity and allows more efficient material movement.

Figure 1

Material flow pattern changes create wear



Ceramic backing. Ceramic backing is a very successful technique to equip a diverter valve for longevity in abrasive pneumatic conveying applications.

The purpose of ceramic backing, as shown in Figure 2, is to offer additional protection to a pneumatic diverter's inlet weldment in applications where the material flow will create substantial wear to the weldment itself. Such accelerated wear is especially prominent in dilute-phase pneumatic conveying. Ceramic backing creates redundancy so that even as materials have abraded through the steel inlet, thick layers of ceramic still remain. The ceramic layer ensures that conveying line pressures are maintained and also prevents material leakage to the atmosphere. In essence, ceramic backing allows a diverter to continue operating in the midst of abrasion rather than requiring constant component replacement in troublesome areas.

The need for ceramic backing is application-specific. Depending on system setup, similar materials can react very differently when exposed to differing air pressures or system configurations.

Ceramic backing also should be applied in a specific way. To avoid turbulence or friction against material flow, which could degrade materials or accelerate ceramic wear, the ceramic layers are smoothed in the direction of material flow. On average, ceramic backing will enhance steel durability, resulting in a 30 to 40 percent longer service life.

Ceramic/epoxy coating. Similar in purpose to ceramic backing, ceramic/epoxy coating, as shown in Figure 3, is an epoxy-based coating mixed with small ceramic beads. The coating is applied to the inlet weldments of a pneumatic diverter to provide greater abrasion resistance. Note that ceramic/epoxy coatings are designed to protect against fine-particle abrasion only; they're less effective when exposed to larger particle sizes.

Figure 2

Ceramic backing on a pneumatic diverter inlet

Reinforced wye. Constructing a diverter valve with a reinforced wye, as shown in Figure 4, is an alternative to using abrasion-resistant backings. A reinforced wye is a traditional wye inlet to which an additional piece of thick, triangular steel has been welded. A reinforced wye can prolong the diverter's useful life, but the technique is often less effective than abrasion-resistant backing.

Straight-leg diverting. Straight-leg diverting is essential to protecting a diverter's inlet weldment in abrasive pneumatic conveying applications. In symmetrical (A-

Figure 3

Ceramic/epoxy coating on a pneumatic diverter inlet

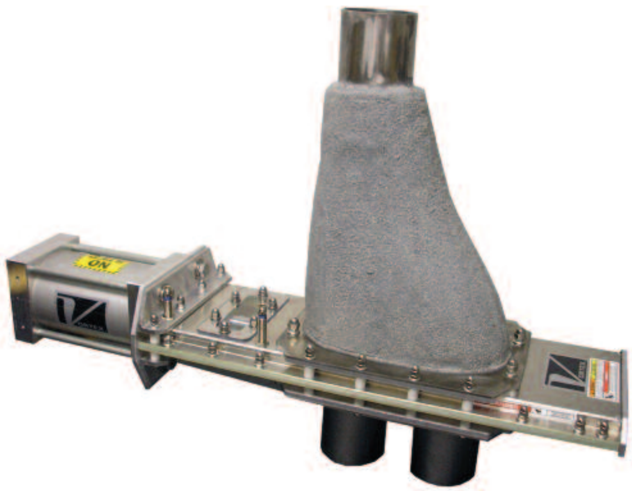
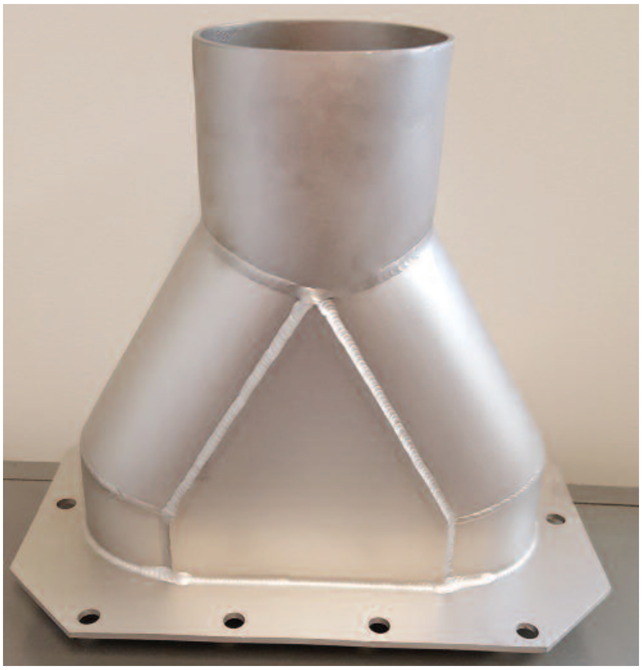


Figure 4

Pneumatic diverter with a reinforced wye



style) diverters, as shown in Figure 5, wear and abrasion are concerns because materials flowing through the inlet often directly impact the area where the outlet legs meet. When handling abrasive materials, this form of continuous abrasion will rapidly wear through a diverter's inlet and create holes. If left unaddressed, those holes can facilitate material leakage and air loss.

To prevent this form of abrasion, pneumatic diverters are often constructed using a straight-leg (K-style) design, as shown in Figure 6. This design is preferable because it allows a straight-through channel for material flow; the outlet legs do not meet in the direct path of material travel.

Generally, symmetrical diverters are used when each destination is diverting or converging similar material quantities. Straight-leg diverters are generally used when the majority of materials are being routed toward a single destination. Opinion on this concept differs, so consulting with a dry bulk material handling expert to determine which design is most suitable for use in your specific application is advised. Do note: This concept of symmetrical versus straight-leg diverters can also be applied in gravity-flow applications.

Figure 5

Symmetrical pneumatic diverter

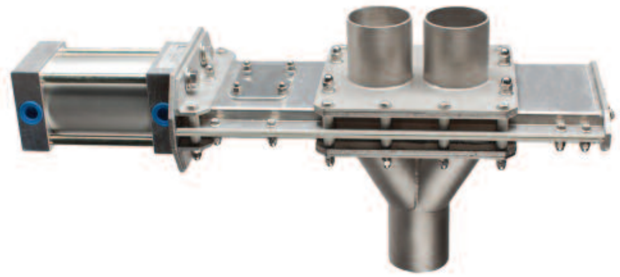
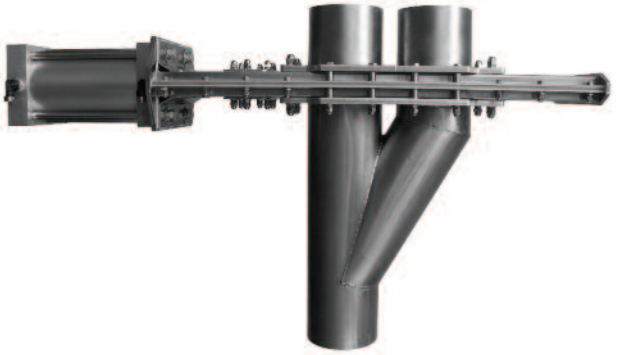


Figure 6

Straight-leg pneumatic diverter



Longer flexible hose. When handling abrasive materials, extending the hose length in a flexible-hose diverter is advised. This reduces the degree of bend in the hose when shifting ports.

With the standard hose length, the degree of bend in the hose can be significant and can impact flow patterns as materials pass through the hose. If the material being handled is abrasive, sharp bends in the hose can become wear points that allow materials to create pinholes and abrade through the hose. By extending the hose length, bends become less pronounced, which creates a more direct path of travel and reduces wear. Do note: Extending hose length also increases the overall height of a flexible hose diverter. This option should only be considered if head space is available.

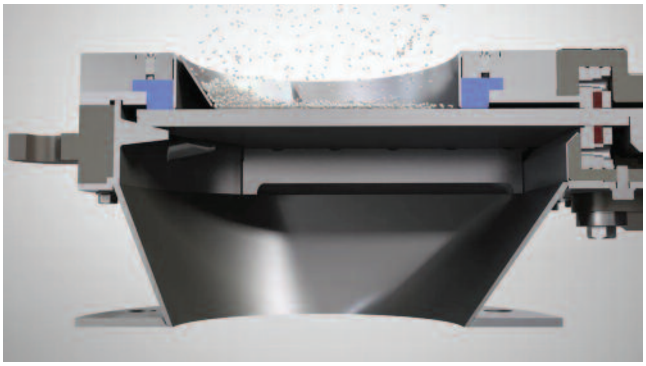
Lifting blade sealing design. To address wear and abrasion in higher-pressure applications, some slide gates are engineered to "lift" the blade into a closed position, as shown in Figure 7. Because the blade lifts into a seat, versus closing against an end seal, the leading edge of the blade never comes in contact with the end of the gate. This feature hinders the blade from packing or jamming abrasive materials against the seals, which decelerates the rate of seal wear.

Displacement pocket sealing design. Also to reduce wear and abrasion in higher-pressure, pneumatic conveying applications, some gates are designed with a displacement pocket, as shown in Figure 8. By closing into a displacement pocket, materials remaining at the blade's leading edge are allowed to fall away into the process line rather than pack into the gate's end seal. To further prevent materials from collecting at the blade's leading edge, some gates are designed with a beveled leading edge.

Blade and seat construction. For especially abrasive applications, some gates are constructed with a metal-

Figure 7

Lifting blade end seal



on-metal blade and seat. This is done using harder metal materials of construction, such as 440 C stainless steel (Rockwell hardness of 60 C).

Gravity-flow applications

When handling abrasive materials in gravity-flow applications, primary wear and abrasion concerns differ from those in pneumatic conveying applications. These concerns include:

- Material contact area: The size and shape of a handled material
- Hardness: The hardness, toughness, and overall stability of a handled material
- Degree of movement: The accelerating velocity of heavy materials dropping from too great a height and creating excessive wear on impacted surfaces

When handling larger, irregularly shaped, or extremely hard materials, be cognizant of how those material characteristics will create and affect wear at equipment impact areas. Fortunately, numerous techniques can help address these issues.

Figure 8

Displacement pocket end seal

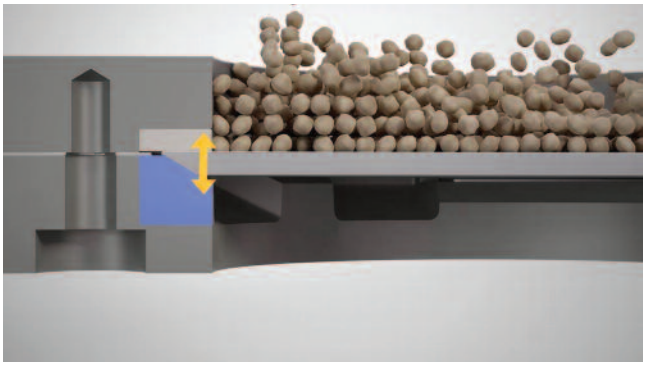
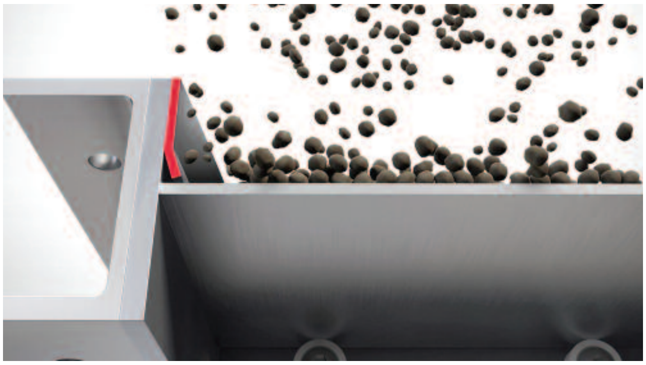


Figure 9

Material-deflector insert



Valve construction. Constructing a diverter valve's body, blade, and material-contact areas from carbon steels or other abrasion-resistant metals will often provide appropriate abrasion resistance and significantly reduce wear. For gravity-flow applications that are especially abrasive, valves can be constructed using even stronger abrasion-resistant metals, such as chromium carbide.

Materials of construction should be selected based on application parameters. Several gauges of steel exist, so it's important to assess a handled material's characteristics and determine which Brinell Hardness Number (BHN) of steel is most appropriate for a valve to withstand wear and abrasion in its specific application.

Material-deflector inserts. When handling abrasive materials in gravity-flow applications, a slide gate can be protected from flowing materials by using a material-deflector insert, as shown in Figure 9. By design, material-deflector inserts direct material flow through the gate's center, which protects gate seals from blast abrasion as materials pass through the valve.

An added benefit of material-deflector inserts is that they create a void between the material, the blade, and the gate's seals. As the slide gate closes, the insert creates a momentary dead pocket. This allows materials remaining at the blade's leading edge to fall away, into the process line below, prior to the blade entering its end seal. Material deflector inserts also hinder abrasive materials from migrating into the gate's seals. Otherwise, materials can pack and abrade the seals and "grind" against the blade to cause premature wear. Do note: Because material-deflector inserts taper inward, the available inlet size will be smaller than the true inlet size, which may decrease the gate's throughput rate.

Abrasion-resistant liners. For added abrasion resistance, some gravity-type diverters use abrasion-resistant liners throughout their interior housing, including the valve's inlet and outlet legs. Although a diverter's construction may naturally make it capable of handling abrasion, these liners provide redundancy and allow materials to abrade replaceable parts rather than the valve itself.

The type of abrasion-resistant liner to use depends on the material(s) handled.

- Abrasion-resistant (AR) steel, as shown in Figure 10. Steel generally has excellent resistance to material abrasion, and AR steel contains extra amounts of chromium and manganese to make it less susceptible to wear. AR steel is available in several grades that vary in hardness and strength — for instance AR 235 or AR 400 — to address the materials being handled. The higher the AR number, the stronger the steel.

- Rubber or polymer, as shown in Figure 11. When handling certain materials, rubber and polymer have the capacity to reduce wear by absorbing material impact. Additionally, these materials reduce noise. Jagged or sharp materials, however, can tear rubber and polymer liners, causing them to fail.
- Special coatings. When handling extremely abrasive materials, metal that has been treated with a wear-resistant coating can be used. Chromium carbide is one such coating.
- Rock box liners, as shown in Figure 12. As materials flow through the inlet, rock box liners allow materials to accumulate in open areas along the diverter's inlet, blade, and outlet legs. Once the openings are filled, subsequent materials will impact upon the collected materials. This reduces wear by allowing material to impact upon itself, rather than continuously abrading upon the diverter's mechanical parts.

An added benefit with abrasion-resistant liners is that they're replaceable. For return-on-investment purposes, these liners provide value because they're the difference between replacing an entire diverter or replacing only less costly parts to significantly extend a diverter's useful life.

The best technique

Selecting proper equipment is critical to the success of any manufacturing process. Misapplied components and deficient designs can cause unexpected maintenance costs and process inefficiencies that negatively impact a company's overall profitability and performance. Dry bulk material characteristics are extremely varied, so no all-encompassing solution

Figure 11

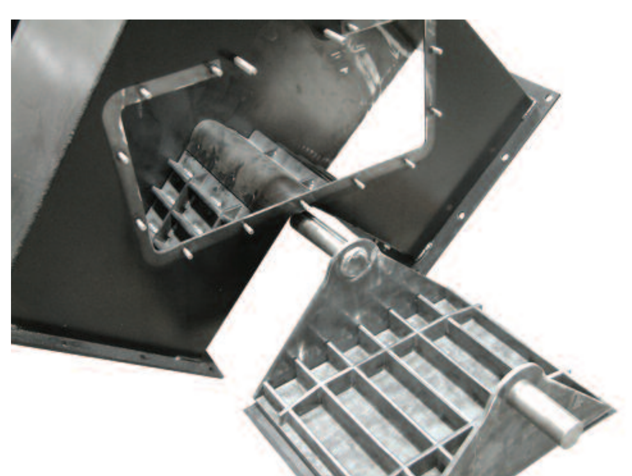
Polymer liner

Figure 10

Abrasion-resistant steel liner

Figure 12

Rock box liner



exists. Consult with dry bulk material handling experts to determine which techniques for wear - and abrasion-resistance will be most effective in your specific application. **PBE**

For further reading

Find more information on this topic in articles listed under "Abrasion resistance" and "Valves" in *Powder and Bulk Engineering*'s comprehensive article index in the December 2017 issue or the Article Archive on *PBE*'s website, www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.)

Kevin R. Peterson *(kevinp@vortexglobal.com) has more than 20 years of experience in the dry bulk solids industry. He has filled many roles at Vortex, including corporate director of marketing, regional director of business development, and director of development for Titan products. Peterson was honored for his work with the Kansas State University Grain Science Department, is an Emeritus Member of the International Association of Operative Millers (IAOM), and is currently serving on the board of directors for the Industrial Minerals Association of North America (IMA-NA). He has written many technical articles and case studies for the industry.*

Logan T. Cameron *(lcameron@vortexglobal.com) is content marketing manager at Vortex. He holds an MBA and a BS degree in business administration and marketing and management, both from Southern Illinois University Edwardsville. He also has written many technical articles and case studies for the industry.*

Vortex
Salina, KS
785-825-7177
www.vortexglobal.com