

## Coperion's wear-resistant diverter valves open up new opportunities for industries where highly abrasive materials are conveyed

### Introduction

A diverter valve is used to divert material from one source to different destinations in a pneumatic conveying system or a gravity pipe. Pellets, granules or fine powders passing through the diverter valve cause wear along the valve's passage, especially with abrasive products as used in the mineral and cement industries. Examples are raw meal, lime, fly ash, by-pass dust, clinker, cement, petcoke, and lignite to name a few. Coperion has identified the main wear factors and has incorporated this knowledge into the design of its diverter valves. Coperion diverter valves make it possible to convey even highly abrasive powder bulk materials economically and reliably, enjoy a long service life and are easy to maintain.

### Erosive wear and mechanisms

Research at Coperion's test facility identified erosive wear as the main type of wear in a diverter valve. Therefore, the main aim is to protect components against this type of wear by adjusting the design and using non-wearing materials in an economical manner.

The type of erosive wear depends on the angle of impact of the product on the surface of the component. Depending on use, this results in sliding erosive wear (angle of flow parallel to the surface), angled erosive wear (angle  $>0^\circ$  and  $<90^\circ$  to the surface), or impact wear (impact angle =  $90^\circ$ ). As shown in Fig. 1, sliding erosive wear and

angled erosive wear result in a cutting action. When angled erosive wear changes to impact wear the wear mechanism shifts from a cutting form of erosion to a shattering form of erosion.

In microcutting or furrowing, grooves are formed into the contacted material due to the shape and angle of the particle. The groove material becomes detached. In microfatigue or ploughing, many particles continually hit the same area on the contacted material which causes detachment of the material over time, a slow fatigue. In microcracking or shattering, highly concentrated hard abrasive particles hit the contacted material and cause cracks which spread very rapidly across the material. The material becomes detached and particles can break apart.

In accordance with these wear mechanisms, hard materials that are resistant to furrowing and ploughing are suitable for use in applications in which sliding and angled erosive wear occur. With the increasing influence of impact wear, hard materials become sensitive to the subsequently prevailing shattering mechanism. Therefore, more elastic materials are suitable for such applications to dampen the impact energy of the particles. The behavior of hard materials such as ceramics and hard alloys is correspondingly positive at flat angles. More ductile materials, such as normal steel, and elastic materials, such as rubber have advantages when used in systems subject to impact wear.

### Product wear properties

The wear properties of conveyed products mainly depend on the following factors:

- > Particle shape
- > Particle size
- > Particle hardness
- > Particle velocity
- > Particle angle (Fig. 1)

Wear primarily occurs with hard products. Even if two products are identical with regard to hardness and particle size, a sharp-edged product can generate a great deal of wear in comparison to a round product contour.

With regard to the particle size, a few large particles result in a higher level of wear than the same quantity by weight of smaller particles. One main reason is that a large particle can damage the surfaces with its high energy levels to a disproportionate degree. In contrast, very small particles generate very low levels of wear, whereby particle sizes of  $<1 \mu\text{m}$  hardly result in any wear at all. A higher conveying velocity therefore results in higher impact velocities and so higher impact energy, which in turn causes a higher level of wear.

### Erosive wear test facility

At Coperion's wear test facility the wear effects on components are examined under realistic conditions. This test facility can be used to examine products ranging from very fine powders to high-wear pellets with a diameter of several millimeters. Conditions in the pipe are simulated over a long acceleration section. The products are shot onto a sample holder on which the various impact angles can be adjusted by a pivoting device.

### Testing wear protection of materials

Products that are often transported in conveying systems and that can be procured again regularly with the same wear intensity are used for testing wear protection materials. When the degree of erosion has been determined by weighing, the loss in volume is calculated and used as a parameter for the performance of the material.

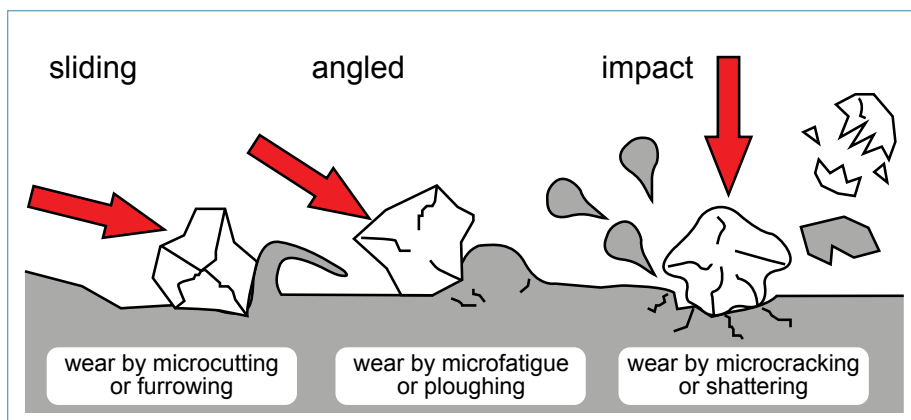


Figure 1 - Effects of particles hitting the housing surface inside the valve

**Materials for wear protection**

Tungsten carbide and ceramics are among the strongest materials for use in pneumatic conveying systems. Tungsten carbide layers have a matrix structure in which the tungsten carbide particles, with their tremendous hardness, are contained in a more ductile nickel matrix. This wear protection is much less sensitive to impact. The more impact-sensitive ceramics have an even higher resistance to wear with flatter impact angles.

Depending on the application type of the tungsten carbide, changes in the matrix structure can result in further considerable improvements in the wear behavior.

**Wear-resistant diverter valves**

There are two design principles for wear-resistant diverter valves.

A ball-type diverter valve, such as the WRK, closes the non-active outlet with a ball. A product cushion forms on the ball that protects the internal components against the wear-intensive flow.

Due to the protective product cushion, the WRK diverter valve only needs high-efficiency wear protection at a few places, for example on the seat of the ball rotor. As a result this diverter valve design is a very inexpensive solution, even for use in operation with highly-abrasive products.

However, due to its design, residues always occur in a ball-type diverter valve after conveying. If this is not acceptable in the application due to cross-contamination, the dual channel diverter valve WZK (Fig. 2) can be used instead. Depending on the wear intensity, the WZK can be protected by using materials such as hardened steel, chilled cast iron, tungsten carbide and also ceramic inserts.

Fig. 3 shows the typical areas for heavy wear in a WRK diverter valve (protected by ceramic rings) and illustrates the function of the product cushion. The lighter areas inside the housing show product material. Without this product build-up, the abrasive particles flowing through the valve would erode the inside surface of the valve. Particles constantly bombarding the ball rotor (rotating part) would cause erosion on this part, too. Further erosion

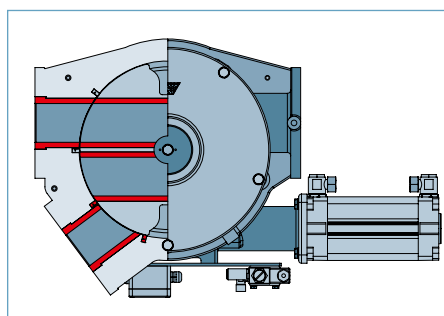


Figure 2 - WZK dual channel diverter valve  
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would typically occur at the outlet around the sealing surface.

**Optimal design**

Coperion has optimized the design of its wear-resistant diverter valves for applications with highly abrasive products. The WRK single channel diverter valve design exploits the effect of product layer protection inside the housing. As shown in Fig. 3, the deliberate product build up in front of the rotor and the grey cast housing protects these parts from being eroded by the conveyed product. Ceramic

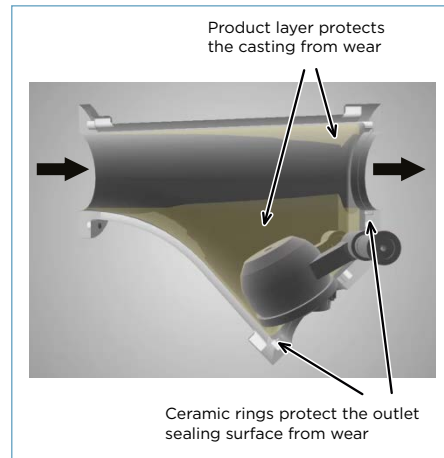


Figure 3 - WRK diverter valve with ceramic wear protection rings in place and product buildup inside the valve during operation

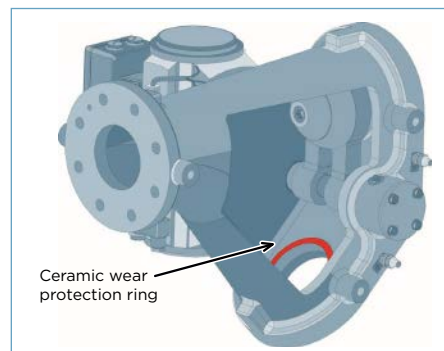


Figure 4 - Perspective view showing the ceramic wear protection ring from inside the diverter valve

rings (Fig. 3 and 4) inserted in the outlet sealing surface prevent erosion and reduce wear at the outlet.

In addition, moving parts inside the diverter valve as well as the number of seals are reduced to a minimum. This reduces wear on the valve and minimizes the required maintenance of parts and related downtime.

The WRK diverter valve has an inspection opening (Fig. 5) through which the rotor of the diverter valve can be replaced very quickly without removing it from service (particularly useful when installed

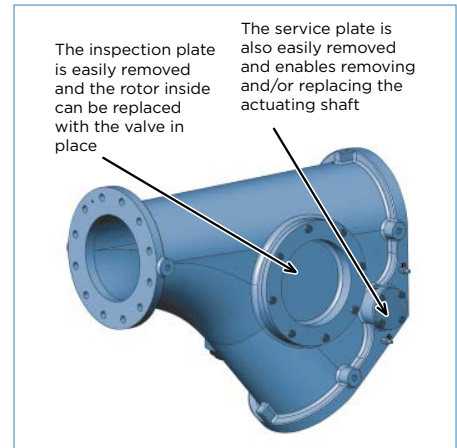


Figure 5 - WRK diverter valve with inspection and service ports

in difficult to reach locations such as high up on a silo). To enable the easy removal of the rotor, the WRK has an additional removable plate to access and remove the actuator shaft. This enables the rotor to be removed and replaced through the inspection opening.

Additionally, the WRK comes with a standard pneumatic drive. The WRK can be ordered with an optional electrical drive which is often used when the valve is installed outside in extreme temperatures, preventing downtime due to freezing air lines, leakages from air lines and/or air supply failure.

**Conclusion**

Coperion's intensive research has identified the causes of wear and the destructive mechanisms inside a diverter valve. The understanding of material flow, new developments in the field of wear resistant materials and Coperion's comprehensive material handling know-how have paved the way for applications which include conveying highly abrasive bulk material in pneumatic conveying systems and gravity pipes. Most efficient wear protection, high reliability, a long service life and easy maintenance make Coperion's diverter valves a rewarding investment and open up new opportunities for industries where highly abrasive materials are handled.

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