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Advances in Conveyor Technology

Choosing the Right Component to Save Energy in Your Cement Plant

An Eye on Energy

How Choosing The Right Component Can Save Energy In Your Cement Plant.

By Keith Kressley, Gary Werth, Frank Speck and Markus Locher

Energy saving is becoming ever more important in the cement industry. Fortunately, today's components for pneumatic conveying provide significant saving opportunities for manufacturers in this industry. Especially the development of new surface wear protection coatings for conveying abrasive materials has broadened the selection of suitable key components which in turn enable substantial savings on energy and costs.

For decades the standard feeding system design relied on the screw pump or on pressure vessels for feeding bulk material into the pneumatic conveying line. New wear protection technologies such as Coperion's DuroProtect concept now bring into focus the cost-efficient rotary air valve, serving as an airlock and for feeding even highly abrasive conveying materials with high conveying pressures. Diverter valves equipped with this type of wear protection further enhance the range of suitable key components.

Today large international companies such as LafargeHolcim, Opterra, Heidelberg Cement, Italcementi, BuzziUnicem, Dyckerhoff and Monarch Cement rely on components incorporating the new wear protection technology.

MAIN ENERGY CONSUMERS IN PNEUMATIC CONVEYING SYSTEMS

Pneumatic conveying is the preferred method for transporting powder products in a cement plant. The two main energy consumers in such a system are easily identified: the air supply system and the device required for feeding the bulk material into the pressurized conveying line.

A typical cement plant has several pneumatic conveying systems installed for handling powders for different applications. The flow diagram in Fig. 1 shows the areas where energy savings can be generated.

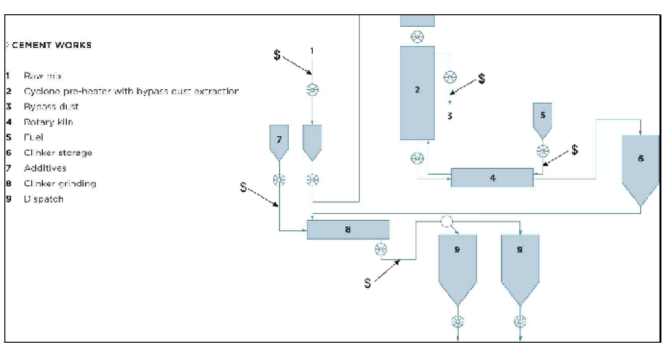

Figure 1 – Typical pneumatic conveying system and saving potentials.

THE INFLUENCE OF WEAR PROTECTION ON ENERGY CONSUMPTION

The extensive research done to pinpoint the main drivers for wear in rotary valves feeding typical materials such as cement, petcoke, fly ash and raw meal, has identified the main factors to be the shape, size and hardness of the bulk material particles.

The research showed that each conveying product has different abrasive properties, suggesting different levels of wear protection for different bulk materials. On the other side, modern materials such as chrome, ceramic and tungsten carbide proved to be the most effective for minimizing wear and extending the life of a rotary valve. The DuroProtect program accounts for these findings by implementing five different protection levels.

WEAR RESISTANCE CONCEPT AVAILABLE IN 5 LEVELS FOR ROTARY VALVES FOR POWDERS

Wear resistance level	Standard	DUROPROTECT® 1	DUROPROTECT® 2	DUROPROTECT® 3	DUROPROTECT® 4	DUROPROTECT® 5
Housing	Cast iron	DUROCHROM®	DUROCHROM®	DUROCHROM®	DUROCHROM®	DUROCERA®
Rotor	D-rotor mild steel	D-rotor mild steel	C-rotor mild steel	C-rotor DUROCHROM®	C-rotor DUROCARB®	C-rotor DUROCARB®
Abrasiveness/ pressure difference	Low					High

Figure 2 - DuroProtect concept.

The conveying of cement with high conveying pressures, for example, calls for a high level of wear protection. The example in Fig. 3 below shows a rotor with chrome-coated blades and tungsten welding on the blade tips. The bore of the housing depicted in Fig. 4 has the highest level of wear protection featuring a jointlessly assembled ceramic layer.

This innovative wear protection system allows for rotary valves to now also be used in wear intensive applications. Rotary valves have lower energy consumption and, owing to their technical features, provide for energy savings also in the air supply system.

Figure 3 – Tungsten carbide welded rotor.

Figure 4 – Jointless assembled ceramic slats in the housing bore.

FEEDING TECHNOLOGY AND ENERGY SAVING

Screw Pump

A screw pump works on the principle of bulk material compaction in a screw barrel to seal the upstream product feeding from the conveying air. High rotational speed of up to 1500 rpm is required and the typically used screw pumps have motor sizes of 300 kW or more, making them big energy consumers. In comparison, the energy consumption of a rotary valve lies between a tenth or even only a twentieth of that of the screw pump.

The average pressure drop in the screw pump is around 300 mbar, which again increases the energy consumption of the air supply equipment.

Figure 5 – Screw pump.

Pressure Vessel

A feeding system based on a single pressure vessel design will force the system to operate in discontinuous mode due to the dead time during vessel refilling. In order to achieve the required average conveying capacity and bridge dead time, the system must be laid out for a higher capacity. This again increases the investment required for the system equipment, especially for air supply and larger piping diameters.

The twin vessel design (Fig. 6) is applied to overcome these disadvantages and to ensure a steady conveying capacity. The concerns here are the high headroom required, especially for higher conveying capacities, and the larger number of instrumentation and shut-off devices which need to be integrated into the controller.

The pressure vessel itself has only insignificant power intake. But pressure loss inside the vessel and the exten-

Figure *6* – Twin pressure vessel.

Rotary Valve

Using rotary valves as feeding devices into pneumatic conveying systems is a sophisticated, reliable and cost-efficient technology, well proven in different applications and in many industries. Various technical features of the rotary valve generate energy savings, some direct, some indirect by reducing energy consumption of the air supply system (blower/compressor). (*See Table A for reference.)*

TECHNICAL ADVANTAGE	CUSTOMER BENEFIT
Rotation speed < 30 rpm	Reduced wear due to low rotation speed of the rotor. This results in less maintenance and downtime costs with a positive effect on the operational expenditure costs.
Low gross weight	No requirement for special foundations or extensive steel structure which reduces the capital expenditure costs for a new conveying system. Easy to dismantle and transport to the workshop for maintenance.
Small size	All rotary valve feeding stations need limited head room which reduces the costs for civil structure. *(e.g. secondary support structure of a silo or upstream process like grinding)*
Low pressure loss at around 50 mbar and low leakage air	Reduces the energy consumption of the air supply equipment.
Low power consumption of the drive motor < 8 kW	Significant reduction of the energy consumption of the drive system.
Continuous feeding	No batch process which means smaller, designed equipment to achieve the requested conveying capacity.

Table A displays technical advantages and customer benefits of a rotary valve.

Small drive motor (direct saving): As there is no compression in a rotary valve, the drive motor uses power only to drive the rotor carrying the filled pockets. A motor capable of conveying cement at a rate of above 200 tph, for example, requires no more than 8 kW.

Low leakage rate (indirect saving): The tight clearance between housing and rotor prevents excessive wear and also accounts for a very low air leakage rate. This reduces the energy consumption of the air supply equipment.

Low pressure drop (indirect saving): The pickup path of a rotary valve has no bends or nozzles. Whereas other device types have a pressure drop of up to 300 mbar, the pressure drop in the rotary valve is around 50 mbar only and reduces the power consumption of the air supply.

The technical features of the rotary valve also generate other savings. The low rotation speed of <30 rpm reduces wear and maintenance costs as well as downtime, having a positive effect on operational expenditure. The low gross weight eliminates the need for special foundations or extensive steel structures, reducing capital expenditure for new systems. Dismantling and transport to the workshop for maintenance are easy. The small size of the rotary valve requires only limited headroom and reduces costs for civil structures, e.g. secondary support structures for a silo or upstream process such as grinding.

There are two different types of rotary valves on the market, suitable for pneumatic conveying systems:

- The **drop-through rotary valve** (Fig. 7), used for grain and powder bulk material and with lower system pressures up to approximately 1 bar.
- The **blow-through rotary valve** (Fig. 8), recommended for conveying pressures above 1 bar, especially for powders. This valve has forced emptying of the pockets and a higher pressure rating.

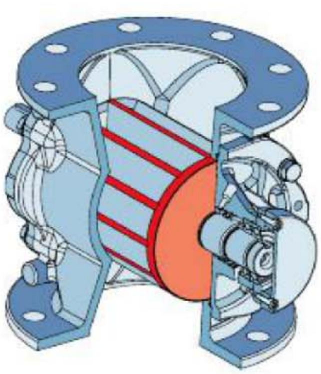

Figure 7 – Drop-through rotary valve.

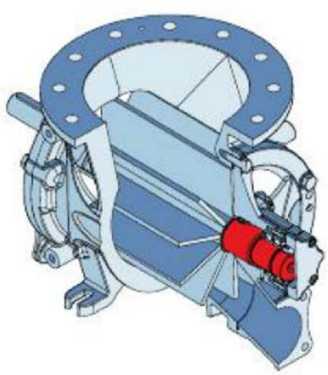

Figure 8 – Blow-through rotary valve.

SAVING ENERGY WITH DIVERTER VALVES

Other neuralgic points with the potential of causing pressure drops in pneumatic conveying systems are the diverter valves. There are two-channel diverter valves (Fig. 9) available with different levels of wear protection including stainless steel, hardened steel, tungsten carbide and even ceramic pipe inserts. Single channel diverter valves (Fig. 10) can incorporate a different wear protection technology.

Here an intentional buildup of bulk material in the valve's bend protects the rotating part and the housing from wear. Both diverter valve types are designed to prevent large pressure drops and thus reduce the energy consumption of the air supply.

In addition, both valve types can be maintained without dismantling and the replacement of wear and tear parts takes less than an hour.

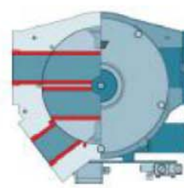

Figure 9 – Two-channel diverter valve WZK with pipe insert.

Figure 10 – One-channel diverter valve WRK with product layer.

CASE STUDIES

Cement Conveying after the Finish Mill

This conveying line following the finish mill in a cement plant in Italy has a conveying capacity of 150 tph and a conveying pressure of around 1 bar. The original feeding device was a screw pump with a power consumption of around 200 kW which was replaced by a ZRC 800 rotary valve with DuroProtect 5 wear protection (ceramic and tungsten carbide). Break even for investment cost was Q3 (see Fig. 12) after startup of the rotary valve, taking into consideration the energy and maintenance cost savings. After a successful test period of two years the customer also replaced the second screw pump below the finish mill by a rotary valve from the same supplier.

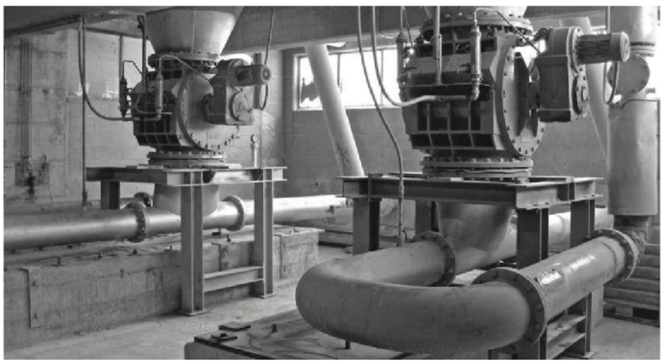

Figure 11 – Rotary valve after the finish mill.

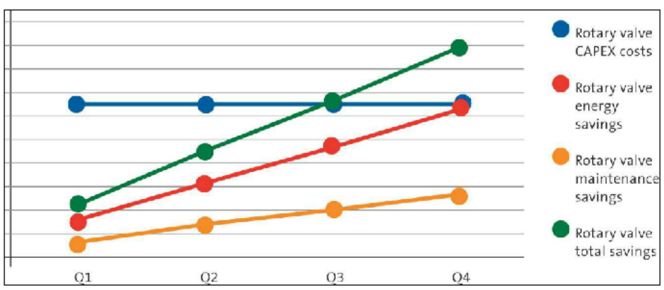

Figure 12 – Payback graph of a screw pump replacement.

Lignite Conveying

At their cement plant "Walzbachtal" in Germany, Opterra installed a new silo and conveying system for lignite. The maximum feeding capacity is 6 tph at a conveying pressure of 0.5 bar (7 psi). In order to implement a feeding airlock also acting as an explosion barrier between the conveying system and the silo, Opterra chose a ZXD 300 rotary valve with DuroProtect 3 featuring a closed-end rotor and chrome plating on the housing and rotor.

The capital expenditure for this single conveying rotary valve solution was lower than the cost for overhauling the existing screw pump and also lower than the CAPEX for an explosion protection rotary valve required upstream of the screw pump. In addition, Opterra has achieved energy savings of more than 90 percent compared to the screw pump concept.

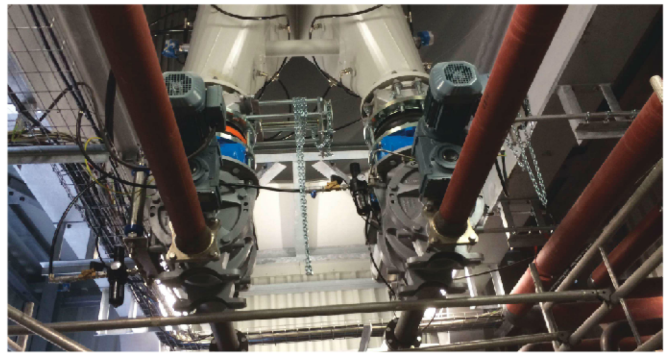

Figure 13 – ZXD 300 DP 3 for lignite conveying (Source: Opterra).

Fly Ash and Limestone Handling

This cement plant in Germany for grinding and mixing had four screw pumps for the handling of fly ash and limestone. Each screw pump had an energy consumption of around 100 kW for achieving the conveying capacity of 50 tph at around 1 bar. The rotary valve applied for the limestone is a ZRC 550 DuroProtect 4 (chrome housing and tungsten carbide rotor) and the rotary valve for the fly ash is a ZRC 550 DuroProtect 5 (ceramic housing and tungsten carbide rotor).

Calculated with an energy price of around $0.87 per kWh and an operation time of 8000 hours per year the annual power savings are around $204,000.

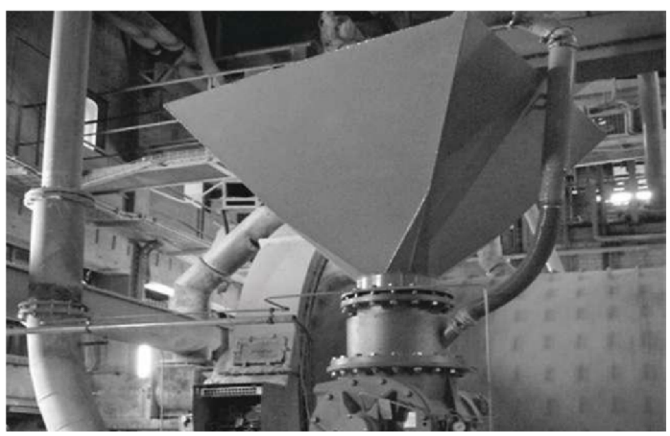

Figure 14 – Fly ash rotary valve.

CONCLUSION

New wear protection technologies and their application in rotary valves are offering new opportunities to reduce the energy consumption in the field of pneumatic conveying.

Keith Kressley, Gary Werth, Frank Speck and Markus Locher are with Coperion K -Tron.