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SUMMARY

The ceramic rotary valve as a tightly closing and wear-resistant feeding device for bulk materials of a pneumatic conveying system represents an ingenious technical development of recent years. The rotary valve replaces the previously widespread screw pump, which is equipped with a compression screw and is generally known for its disproportionately high drive power and high wear. Kreisel GmbH & Co. KG, with its headquarters in the Upper Lusatian town of Krauschwitz, has installed more than 100 of these ceramic rotary valves in the cement and lime industry with great success in recent years. In the contribution, seven application examples are described to document the great flexibility and versatility of this new material feeding device. One example is the use of four ceramic rotary valves in the Karsdorf cement works, a plant of the CRH Group, where the pneumatic raw meal feeding of two double-string preheaters is now carried out using this new rotary valve. By replacing the screw pumps previously used, the power requirement could be reduced from a total of 640 kW to a power value of 16 kW, which corresponds to a saving in electrical energy of 97.5 % and is associated with annual savings in operating and maintenance costs amounting to € 345 000. Another example is the use of a pressure shock resistant airlock for the pneumatic conveying of ground petroleum coke to the kiln burner of a clinker line in the Matera cement plant in Italy. In addition to saving electrical energy, the main focus of this investment was to increase plant safety and availability. The new ceramic rotary valve from Kreisel is available for pneumatic conveying systems with capacities of up to 200 m³/h and conveying distances of 1 000 m.

ZUSAMMENFASSUNG

Die Keramik-Zellenradschleuse als dicht schließende und Verschleiß resistente Aufgabevorrichtung für Schüttgüter einer pneumatischen Förderanlage stellt eine interessante technische Entwicklung der letzten Jahre dar. Die Schleuse löst die bislang verbreitete Schneckenpumpe ab, die mit einer Stopfschneckenwelle ausgerüstet, für ihre überproportional hohe Antriebsleistung und großen Verschleiß allgemein bekannt ist. Die Kreisel GmbH & Co. KG mit ihrem Firmensitz im Oberlausitzer Ort Krauschwitz, hat in den vergangenen Jahren mehr als 100 dieser Keramik-Zellenradschleusen vor allem in der Zement- und Kalkindustrie mit großem Erfolg installiert. In dem Beitrag werden sieben Einsatzbeispiele beschrieben, um die große Flexibilität und Vielseitigkeit dieser neuen Material-Aufgabevorrichtung zu dokumentieren. Beispielhaft sei hier der Einsatz von vier Keramik-Zellenradschleusen im Zementwerk Karsdorf, einem Werk der CRH Gruppe, genannt, wo heute die pneumatische Rohmehlbeschickung von zwei doppelflutigen Vorwärmern unter Einsatz dieser neuen Schleuse erfolgt. Durch den Austausch der bislang eingesetzten Schneckenpumpen konnte der Leistungsbedarf von insgesamt 640 kW auf einen Leistungswert von 16 kW reduziert werden, was einer Einsparung an elektrischer Energie von 97,5 % entspricht und mit jährlichen Einsparungen an Betriebs-und Wartungskosten in Höhe von 345 000 € verbunden ist. Ein weiteres Beispiel ist etwa der Einsatz einer druckstoßfesten Schleuse für die pneumatische Förderung von gemahlenem Petrolkoks zum Ofenbrenner einer Klinkerlinie im italienischen Zementwerk Matera. Das Hauptaugenmerk bei dieser Investition bestand neben der Einsparung von elektrischer Energie in der Erhöhung der Anlagensicherheit und Verfügbarkeit. Die neue Keramik-Schleuse von Kreisel steht für pneumatische Förderanlagen mit Leistungen bis zu 200 m³/h und Förderstrecken von 1 000 m zur Verfügung.

Operating experience with over 100 ceramic rotary valves for pneumatic transport

Betriebserfahrungen mit über 100 Keramik-Zellenradschleusen für den pneumatischen Transport

1 Introduction

In a fast-moving world that demands ever more sustainable solutions, the bulk solids sector is also called upon to adapt to new conditions, optimise existing plants, minimise maintenance and downtimes and significantly reduce energy and resource consumption. Replacing screw pumps with ceramic rotary valves for pneumatic conveying systems makes it possible to significantly improve plant operation in terms of energy. In addition to energy savings, resources are conserved because the further development of industrial ceramics has made it possible to realise wear-resistant rotary valves with long service lives. Seven projects carried out with ceramic rotary valves with very different requirements by Kreisel GmbH & Co KG, based in Krauschwitz, Oberlausitz, are described below. It becomes apparent that there are numerous other reasons for using ceramic rotary valves besides energy savings.

2 Flexibility is everything [1]

The cement group CRH decided to use ceramic rotary valves in its Karsdorf plant back in 2015 in order to increase the efficiency and availability of its pneumatic conveying systems. The Karsdorf plant is located about 70 km southwest of Leipzig and is one of the largest cement plants in Germany.

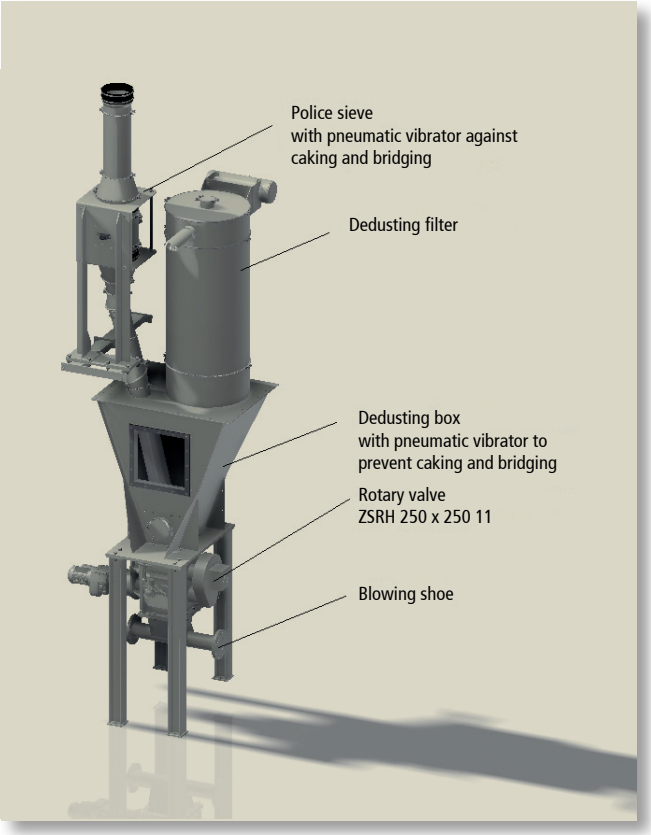

Figure 1: Conveying station for pneumatic transport of bypass dust

The first project to be realised was the dosing and conveying of bypass dust from the storage silo to the mills. Due to the cohesive and sticky properties of the dust with a chlorine content of up to 18 %, this project posed particularly high challenges. The screw pumps installed until then had to be cleaned manually every fortnight due to caking caused by the chlorine content of the bypass dust, which meant long downtimes and high maintenance costs. By replacing the screw pumps with self-cleaning and highly wear-resistant rotary valves, it was finally possible to achieve trouble-free operation with fluctuating bulk material properties with a dosing accuracy of 1 %. Plant areas, such as the chutes, which are usually uncritical for bulk materials such as cement, lime, fly ash or filter dust, had to be considered separately during the project. Years of experience had shown that these parts of the plant often become clogged and can lead to unwanted plant shutdowns. Taking into account the experience of the plant operator, Kreisel therefore designed these critical areas in such a way that trouble-free operation could be guaranteed after the conversion. For example, the feed hopper in front of the self-cleaning and highly wear-resistant rotary valves was designed with an internal vibration hopper, which prevented caking. ❯ Fig. 1 shows the design of the system including a police filter for the pre-separation of foreign materials.

In a second project, the raw meal feeding of the preheater was changed. At the Karsdorf plant, the two kiln lines are located about 80 m away from the raw meal silos. Up to now, the raw meal was transported to the two-line preheaters pneumatically, using two screw pumps each. The drives of these four screw pumps had a total output of 640 kW. In contrast, the four new ceramic rotary valves have a combined drive power of only 16 kW. This means an energy saving of 97.5 %, which saves operating and maintenance costs of € 345 000 per year. ❯ Fig. 2 shows the layout of the new feeding system under the raw meal silos. A new ceramic rotary valve can be seen in the background. In the foreground, positioned centrally under the silo, is the feed system that remained as a standby by means of a screw pump.

Figure 2: Preheater feed by means of ceramic rotary valve in the background and remaining standby screw pump in the foreground

In a third project, a filter dust discharge system for thallium reduction was realised in the course of a plant expansion in the interest of environmental protection. For this purpose, dust with temperatures of 200 °C is fed into two pneumatic conveyor systems with the help of screw valves, which feed a storage silo with a capacity of 300 m^3. The dust is temporarily stored in these silos and added to the bypass dust. For this purpose, the dust is removed from the silo by means of a flow control gate and fed to the downstream rotary dosing unit. The dosing unit doses the filter dust, which is then pneumatically fed at a conveying rate in the range of 1.0 to 5.0 t/h to a bypass dust system approx. 180 m away. ❯ Fig. 3 shows the silo outlet with downstream dosing unit in 3D planning.

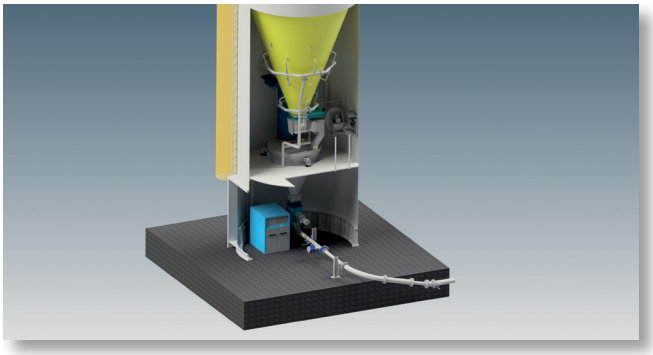

Figure 3: Silo discharge with downstream metering and pneumatic conveying

CRH currently operates eleven highly wear-resistant Kreisel ceramic rotary valves at the Karsdorf site for the transport of cement, raw meal, bypass dust and filter dust and, by saving electrical energy, reduces CO_2 emissions by 1 700 t annually.

3 Strong against wear

On the plant site of ThyssenKrupp Steel Europe in Duisburg, the building materials group LafargeHolcim operates a grinding and mixing plant. In 2019, LafargeHolcim asked Kreisel to evaluate the dedusting of a clinker dust dosing system. The analysis revealed that an installed rotary feeder for feeding a pneumatic conveying system proved unsuitable for the application. The highly abrasive behaviour of the clinker dust led to an overload of the installed filter system after a short period of operation, caused by the heavy wear on the rotary valve used. In addition to the gland packings in the bearings of the rotary valve, which proved to be unsuitable and caused an extremely high dust leakage into the environment (❯ Fig. 4), the rotary valve was also not sufficiently protected against wear, which also led to a strong increase in the amount of leakage gas through the rotary valve to the filter, which was affected in its function after a short time. After using a ceramic rotary valve (❯ Fig. 5) and making the necessary adjustments, the rebuilt system was put into operation in May 2019 and has proven itself to date with a delivery rate of up to 18 t/h without any problems.

Figure 4: Dust escaping from the defective rotary valve

Figure 5: View of the new wear-protected ceramic rotary valve

Figure 6: Conveying station for the pneumatic transport of white fine lime

Table 1: Technical data of the four installed pneumatic conveying systems at Müllerkalk and Wotan cement

Designation	Unit	Cement	Limestone powder	White fine lime	Separator dust
Conveying capacity	t/h	50.0	37.5	15.0	2.0
Total conveying distance	m	310	200	330	300
Total conveying height	m	70	40	45	45
No. of receiving points		1	2	3	2

4 Many applications one solution [2]

Since 2015, Nikolaus Müller Kalkwerk-Natursteinwerke GmbH & Co KG has been operating four pneumatic conveying systems (❯ Table 1) at the Üxheim-Ahütte site, which are equipped with ceramic rotary valves. The management of the Müllerkalk and Wotan Zement plants, decided in 2014 to use Kreisel's conveying technology, which is not only energy-saving, but could also be easily integrated into the existing plants. Due to the local conditions, the pipe routing was particularly challenging. In addition to many starting points for the conveyance, the limited space available also had to be taken into account. By laying two pipelines underground and installing Kreisel rotary valves, it was possible to accommodate the confined space conditions. ❯ Fig. 6 shows the pneumatic conveying system with lateral silo discharge for conveying white fine lime over a conveying distance of 330 m. Advantageously, the conveying stations could be positioned on the existing platforms without additional steel construction.

5 Accuracy when it counts

With eleven cement plants in South Africa, Pretoria Portland Cement Ltd is one of the largest cement manufacturers in the country. At the Jupiter location in Germiston near Johannesburg, the dosing capacity of fly ash for feeding the cement mills was to be increased in 2018. In this context, the existing screw pump for feeding a pneumatic conveying system was to be replaced by a ceramic rotary valve. For this purpose, a weighing hopper with associated control system was installed for a dosing capacity of 34 t/h. Directly below the weighing hopper, the frequency-controlled ceramic rotary valve was positioned, which simultaneously functions as a control device and a feed device into the pneumatic conveying line. By replacing the screw pump, the existing blower could continue to be used to supply the pneumatic conveying system with compressed air. ❯ Fig. 7 shows the flow diagram of the new fly ash dosing system, ❯ Fig. 8 the old dosing and conveying system with the leaking screw pump, ❯ Fig. 9 the new dosing ceramic rotary feeder.

6 Safety is paramount

The Italian cement manufacturer Italcementi, which today belongs to HeidelbergCement, fires the kiln system in its cement plant at the Matera location with petroleum coke. Due to a faulty design and unsuitable pipe routing, pulsations occurred repeatedly in the past when the kiln burner was charged, which led to insufficient combustion with associated CO peaks. In not infrequent cases, an explosive atmosphere was formed, which resulted in a shutdown of the kiln plant. In addition to the possibility of significant energy savings, the main focus of this project was therefore on plant safety and availability. At the same time, this project

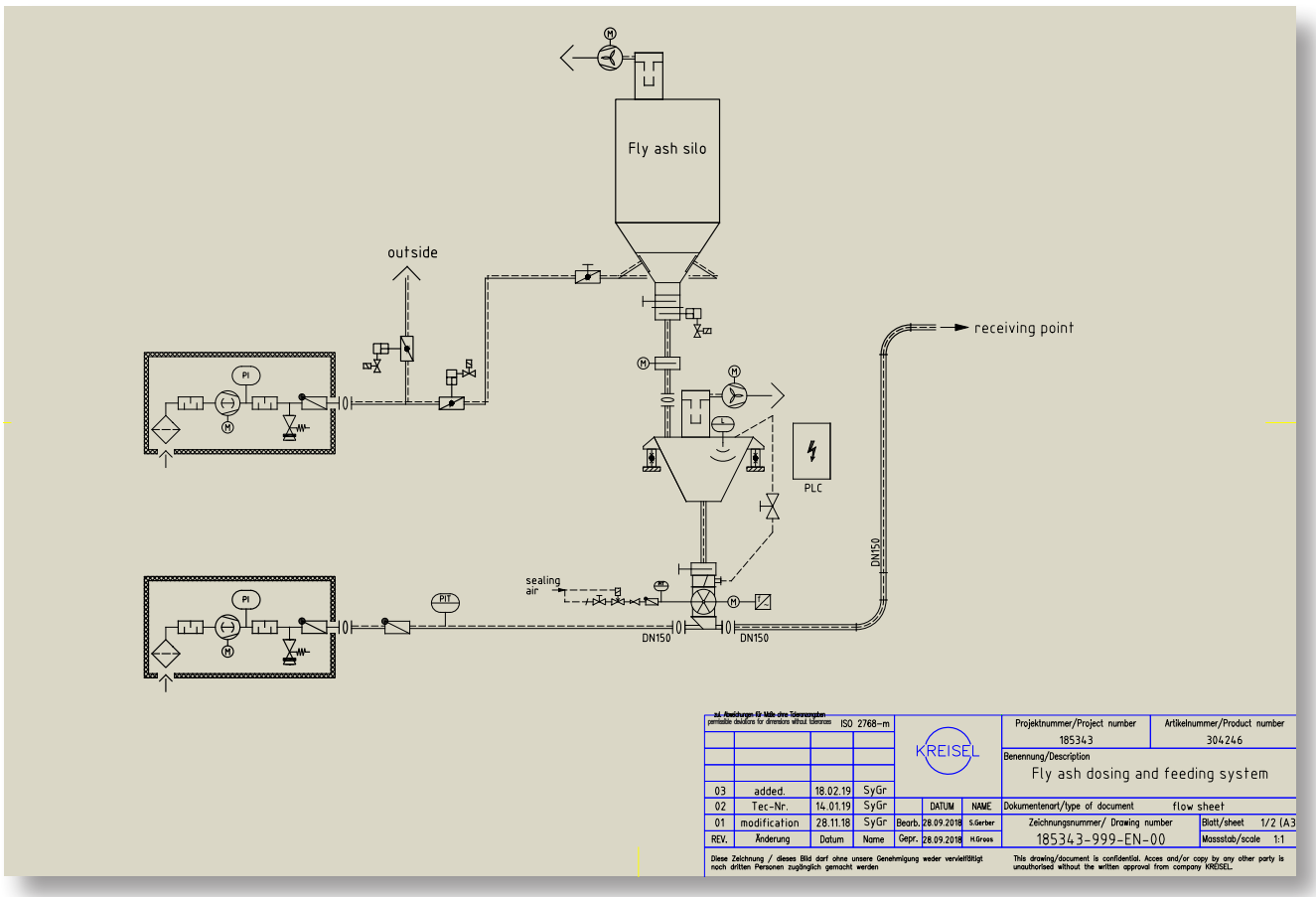

Figure 7: Flow diagram of fly ash dosing

Figure 8: Fly ash metering by means of a screw pump before the conversion

Figure 9: Fly ash metering by means of ceramic rotary valve after conversion

provided evidence that tightly closing ceramic rotary valves are also suitable as infeed elements for burner feeds. Arguments about the occurrence of pulsations caused by the portion-wise discharge of the bulk material from the rotary valve chambers into the conveying line could be refuted several times. The discharge of the petroleum coke via the cellular wheel is so uniform that pressure pulsations could not be confirmed by CO measurements. By replacing the screw pump with a highly wear-resistant and pressure-shock-resistant rotary valve from Kreisel, 80 kW could be saved in the drive power. It should be explicitly mentioned that the conveying line, with a length of 170 m and sections running vertically up and down, is probably one of the longest lines in a burner feeding system in Europe.

7 Openness to new developments

Cement contains hexavalent chromium (chromate) of up to 30 ppm, depending on the nature of the raw materials used and the conditions during clinker production. In this water-soluble form, chromium can penetrate the human skin and cause allergic chromate dermatitis, known as mason's scabies [3]. To prevent this dangerous mason's scabies, the cement industry has been using iron(II) sulphate monohydrate to chemically bind the chromium since Directive 2003/53/EC EG of 17 January 2005 came into force. At Spenner GmbH und Co. KG in Erwitte, a conveying system had been used to feed the mills, which after years of use, despite intensive maintenance, did not provide satisfactory tightness. Kreisel therefore replaced the existing system with a dust-tight ceramic rotary valve. Since then, the mills have been fed with iron(II) sulphate monohydrate without any problems. ❯ Fig. 10 shows the pneumatic conveying system below the silo outlet from the 3D planning phase.

8 Solutions for not everyday dosing and conveying problems

The Amöneburg cement plant is located directly near the Rhine and is the oldest cement plant of Dyckerhoff GmbH. It was founded in Wiesbaden in 1864 and is still in operation today. Due to the tightening of the TA Luft (Technical Instructions on Air Quality Control), Dyckerhoff GmbH changed the dedusting technology in its Amöneburg plant, which resulted in significantly more filter dust. In order to be able to temporarily store the accumulating filter dust, an existing 5-chamber silo was used, for which Kreisel planned the dosing and conveying technology downstream of the silo. At the site of a screw pump, two pneumatic conveying systems from Kreisel with upstream dosing systems from Schenck were installed, which were designed for conveying capacities in the range of 1.2 to 3.5 t/h. The filter dust is now extracted from silo chambers 4 and 5 via adapted air conveyors and fed to the new conveying systems. ❯ Figs. 11 and 12 show the plant layout before and after the conversion.

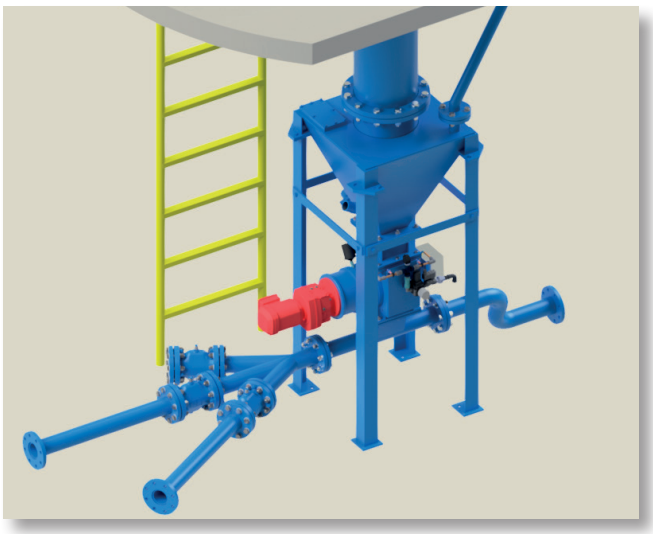

Figure 10: Conveyor system at Spenner GmbH & Co. KG for $Fe(II)SO_4$

Figure 11: Pneumatic conveying of filter dust using a screw pump before conversion

Figure 12: Schenck metering with downstream ceramic rotary valves for feeding a pneumatic conveying system after conversion

9 Concluding remarks

With the installation of more than 100 ceramic rotary valves for the material feed of pneumatic conveying systems as a replacement for the screw pump, Kreisel has already been able to save electrical power amounting to 3.4 MW, which corresponds to a reduction in energy consumption of 93 %. These high savings in electrical energy significantly reduce CO_2 emissions. The operating time of a rotary valve averages 8 000 h/a, which corresponds to an annual CO_2 reduction of 13 000 t.

The Kreisel ceramic rotary valve for material feed in the pneumatic conveying of bulk materials is a very versatile and flexible technical solution. Suitable for almost all bulk materials, the tightly closing and wear-resistant rotary valve can be used very successfully in pneumatic conveying systems with conveying capacities of up to 200 m^3/h over distances of up to 1 000 m.

LITERATURE

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