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Versatile grinding: Latest operating results of the MVR vertical roller mill

Vielseitige Mahlung:

Neueste Betriebsergebnisse von der MVR-Vertikal-Rollenmühle

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SUMMARY

Cement is the most common building material. The CO_2 footprint of a cement plant is important und needs to be reduced as much as possible due to market regulations, investor requirements and for compliance reasons. The cement industry is challenged and needs solutions to produce energy efficient and sustainable cement. Therefore, versatile systems with continuous development for energy efficiency and sustainability are required. For grinding of raw materials, solid fuels and cements, the vertical roller mill (VRM) is one of the most energy efficient grinding systems available. The combination of three process steps in one system – drying, grinding, separating – makes it very versatile with regard to handling dry and moist feed materials, grinding to very high fineness, creating the product properties required by the different market areas. Cements low in clinker content have been produced and developed for decades, but well known supplementary cementitious materials are becoming less available e.g. fly ash and blastfurnace slag. With the introduction of the MVR mill in 2010 to the market, a new concept was available for very high throughput rates. But the MVR mill is also able to grind very small throughputs depending on the versatile module concept. The MPS mill from Gebr. Pfeiffer SE, well known and proven for decades, was partially replaced by the MVR mill. The series of MVR mills cover a wide range of small to large capacities, very fast time to the market with the ready2grind system and a versatile system for many feed material applications. This article gives an overview about MVR mill features and developments, production flexibility and several operational data.

ZUSAMMENFASSUNG

Zement ist der meist verbreitete Baustoff. Ein Zementwerk verfügt über einen CO_2-Fußabdruck, der aufgrund von bestehenden Marktverordnungen, Investitionserfordernissen sowie aus Nachhaltigkeitsgründen so weit als möglich reduziert werden muss. Die Zementindustrie steht damit vor großen Herausforderungen und benötigt Lösungen für eine energieeffiziente und umweltfreundliche Produktion von Zement. Zur Erzielung einer hohen Energieeffizienz und Nachhaltigkeit ist deshalb auch die kontinuierliche Entwicklung von universellen Mahlsystemen erforderlich. Zur Mahlung von Zementrohstoffen, von festen Brennstoffen sowie Zementklinkern steht heute die Vertikal-Rollenmühle (VRM) als eines der energieeffizientesten Mahlsysteme zur Verfügung. Die Kombination der drei Prozessstufen der Trocknung, Mahlung und Sichtung in einer einzigen Maschine macht diese Mühle sehr vielseitig geeignet in Bezug auf das Handling von trockenen und feuchten Mahlgütern, in Bezug auf die Erzielung von sehr hohen Mahlfeinheiten und Fertigprodukteigenschaften, wie sie in verschiedenen Marktbereichen heute gefordert werden. Vor Jahrzehnten bereits eingeführt, werden Zemente zunehmend mit einem niedrigen Klinkeranteil produziert, wobei solche ergänzenden zementartigen Materialien (SCM) wie z.B. Flugaschen und Hüttensande immer weniger zur Verfügung stehen. Mit der Markteinführung der MVR- Vertikal-Rollenmühle im Jahr 2010 wurde ein neues Mühlenkonzept für sehr hohe Durchsätze verfügbar, wobei die Mühle dank ihres universellen Modell-Konzepts auch für sehr kleine Durchsätze geeignet ist. Die Entwicklung der MVR-Mühle baut partiell auf die über Jahrzehnte bekannte MPS-Mühle auf, deren Typenreihe einen breiten Bereich von kleinen zu großen Durchsätzen abdeckt. Auf den Markt reagierend, wurde in sehr kurzer Zeit mit dem so genannten ready2grind System ein für viele Mahlgut-Applikationen einsetzbares Mahlsystem entwickelt. Der Beitrag vermittelt einen Überblick über die Entwicklung, die charakteristischen Merkmale und Flexibilität der MVR-Mühle in der Produktion, dokumentiert durch zahlreiche Betriebsdaten.

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1 Introduction

The cement industry, like every other industry, is driven by best solutions for efficiency, sustainability and digitization. For grinding of raw materials, solid fuels and cements the vertical roller mill (VRM) is one of the most energy efficient grinding systems available. The combination of three process steps in one system – drying, grinding, separating – makes it very versatile with regard to handling dry and moist feed materials, grinding to very high fineness, creating the product properties required by the different market areas.

With the introduction of the MVR mill in 2010 to the market a new concept was available for very high throughput rates. By using a larger diameter, a larger contact area resulting from roller size and / or number of rollers, a faster rotational speed and higher hydraulic grinding forces, the mill capacity can be increased.

The MVR mill is also able to grind very small throughputs depending on the versatile module concept. The MPS mill, well known and proven for decades, was partially replaced by the MVR mill. This mill type is equipped with cylindrical rollers and a flat grinding table; each roller has its own hydraulic suspension and roller arm. The modular design of the MVR mill comprising four to six grinding rollers allows the continuation of mill operation even if one roller module is not available. That concept is known as active redundancy. Meanwhile nearly 100 MVR mills are in operation or in order execution. The world map in ◗ Fig. 1 shows the geographic positions of MVR mill installations.

2 Design features and development

The installed power of vertical roller mills was previously limited due to the design of traditional planetary gearboxes. With the development of a new modular drive system the installed power was upgraded to a much higher level. The MultiDrive® was launched with the MVR mill in 2010. The mill is driven through a girth gear flanged to the grinding bowl by up to six actively redundant drive units with a total installed power of up to 18000 kW (◗ Fig. 2). Each drive unit consists of an electric motor, coupling and gear unit. The grinding forces are transmitted to the foundation via a conventional plain bearing without placing any loads on the gear units. Therefore, the gear units are not exposed to the grinding forces. Both drives and gear unit can be removed individually from the system and the mill can continue to grind. Together with the rollers, which can also be taken out individually, the highest level of availability is achieved.

Figure 1: World map with MVR mills

Figure 2: MVR 6700 C-6 mill with MultiDrive®

Product development is always oriented on the needs of clients. Recent steps have been e.g. an increase in power density of the current MVR series. In general the vertical roller mill sizes are named after the diameter of the grinding table. The absorbed mill power is the result of throughput multiplied by specific power consumption. The power density is the ratio of mill power and mill size. A lower power density results in a bigger mill size for the same required capacity. For example an MPS mill of 6.6 m diameter supplied 40 years ago had an installed drive of 2700 kW. Today, the mill is specified with a diameter of approx. 4.0 m with the same installed drive power. As clients always look for the best solution in regard to techno – commercial balance, the target is the most compact design. Therefore, power density is the main figure to appraise the selection of a mill.

Not only the mill itself, but also all components and the complete grinding plant are subject to further development: the separation efficiency of the classifiers has been increased; with a higher specific dust load, the volume flow through the mill has been reduced which leads to a reduced gas volume flow in the plant and results in a lower fan power consumption.

3 Production flexibility

In terms of product properties the requirements of clients are depending on market requirements. Cement is sold on the basis of strength and workability and fineness in combination with particle size distribution. In most markets the flexibility in cement characteristics or properties is always required for a wide portfolio of products. With the tendency to decrease the clinker content as much as possible, additives i.e. supplementary cementitious materials (SCM) are used depending on the availability in each market.

Vertical roller mills are very flexible for grinding feed materials such as clinker, limestone, granulated blast furnace slag (GBFS), pozzolana, fly ash etc. with different properties. When feeding moist materials, a heated rotary lock will be installed, when feeding dry and fine materials an additional feeding point is planned at the classifier housing. Therefore, the issue for inter-grinding or separate grinding is still in focus. When inter-grinding clinker and GBFS the finer and more reactive fractions contain small proportions of GBFS. The decision for the mode of grinding has to be taken carefully. The properties of e.g. fly ash and GBFS vary within a wide range and therefore, a tailor-made production mode with specific fineness of the finished product is necessary to get the required final product quality.

Many plants equipped with MVR vertical roller mills have decided for separate grinding such as an example in Australia, where an MVR 6000 C-6 mill has been producing GGBFS and cement of the quality CEM I since 2014. In India many plants switch over from inter-grinding to separate grinding and vice versa. SCM as limestone and blast furnace slag are also used for cement production by both inter- and separate grinding. An MVR 6700 C-6 mill installed in Algeria produces mainly limestone-composite cements by separate grinding. The limestone is ground in a raw material mill MVR 6000 R-6 and is injected at the classifier outlet of the cement mill MVR 6700 C-6. Inter-grinding is handled with the MVR 6700 C-6 mill itself.

In the past decades the vertical roller mill has been replacing many ball mill grinding systems. Achieving the same quality of cement produced in ball mills and vertical roller mills was essential for the success of this type of mill for cement grinding. This was traced back by achieving the same or similar Particle Size Distribution (PSD).The PSD curve can be characterized by parameters such as slope and position parameters according to RRSB evaluation. The slope characterizes the steepness of the PSD and the position parameter gives information about the fineness overall. Fineness is also characterized with sieve residue figures and Blaine measurement. When using laser diffraction equipment, the range resp. quantity of particles between for example 3 to 30 µm is used to characterize the product. These physical properties give a first indication for the quality of the produced cement.

By installation of a high efficiency separator the differences in the PSD curve between ball mill and vertical roller mill are quite low. In a vertical roller mill the PSD curve can be adjusted by different parameters: e.g. by increasing the working pressure the quantity of fines can be increased. By decreasing the volume flow the PSD curve is becoming wider.

But nowadays it is clear that the PSD curve is not the only factor to impact the properties of the finished product. Levers to pull for achieving the required product quality are mainly coming from the feed material and the physical properties. The feed material describes the clinker with its chemistry, especially the C_3A-content, the sourcing of the clinker implicating possible moisture and subsequently pre-hydration. This is very important due to the number of grinding terminals installed in the past. The sulfate agent needs a proportion of dihydrate, hemihydrate and anhydrite – balanced on the clinker properties. Additional factors are the SCMs (Supplementary Cementitious Materials) which influence the grindability and operational behavior plus the need for adequate reactivity.

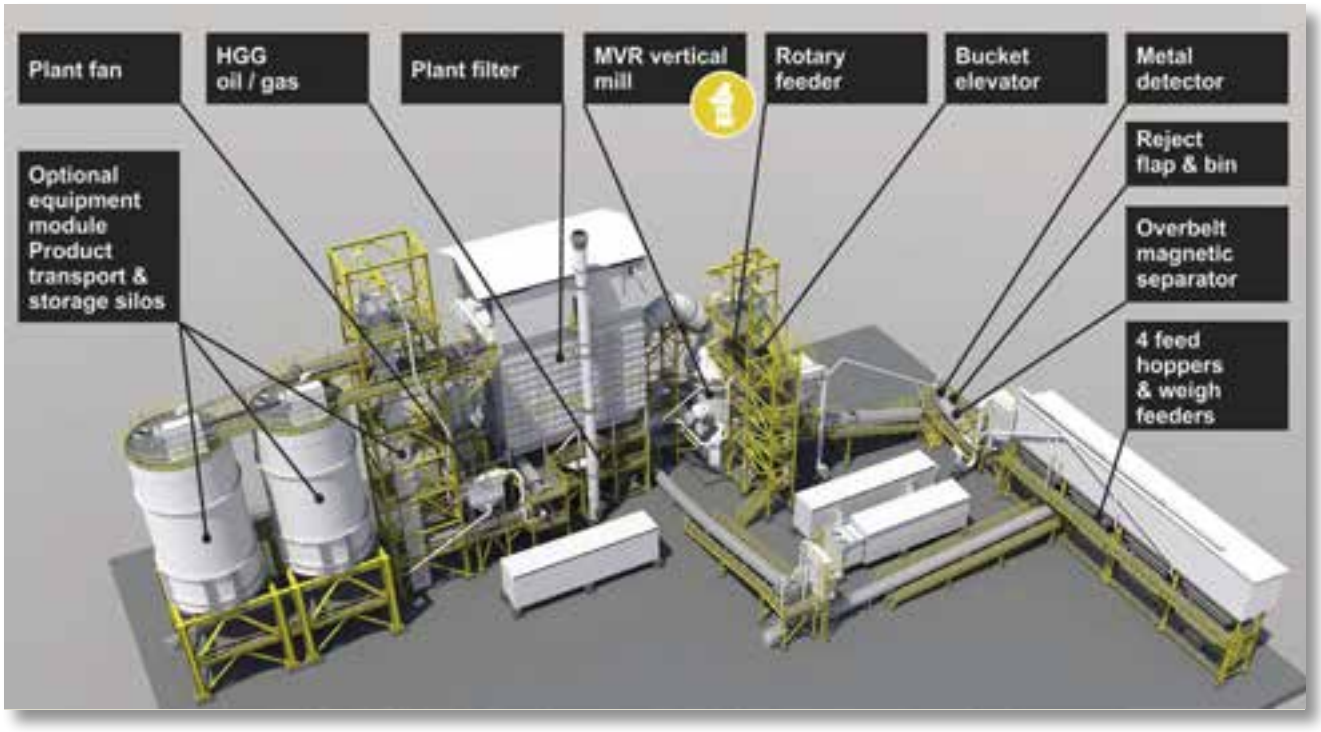

Figure 3: Exemplary layout of a ready2grind plant

4 Compact grinding plants – ready2grind

After the late 2000 crisis the clinker overcapacity was realized as severe. At the same time, several markets with comparably poor infrastructure were demanding small capacities in the range of approx. 20 t/h. The compact grinding unit, the so-called ready2grind plant [1], developed by Gebr. Pfeiffer, was the response to market demand.

With the short time to market and the modular, pre-fabricated plant, project completion is very fast. These compact ready2grind plants are appropriate for remote areas or when cement production needs to be very close to cement consumers, even if the infrastructure is challenging.

The pre-assembled construction of the modules with standard container dimensions makes precisely these factors possible in comparison to conventional grinding plants. Moreover, the majority of the steel construction for the grinding plant is integrated in the container structure. The electrical control system is also pre-assembled and wired and arrives at the construction site in an air-conditioned container. The savings resulting from the modular and standardized construction are up to 35 % as compared to conventionally built plants. The entire system can be adapted to suit the customer's needs in terms of material feed and product handling as well as the on-site layout, thanks to its modularity [1]. A basic configuration is shown in ❱ Fig. 3.

The installation sizes vary from 20 up to more than 90 t/h. The most common ready2grind plant type is the R2G 2500 C-4 with a production rate from 50 to 79 t/h of cement, depending on composition and product fineness. ❱ Figs. 4 and 5 show pictures of ready2grind plants with MVR 2500 C-4.

Figure 4: ready2grind plant equipped with an MVR 2500 C-4 mill in Costa Rica

Figure 5: ready2grind plant with an MVR 2500 C-4 mill during erection in the Philippines

Table 1: Production rates of MVR 2500 C-4 mills

Type	Unit	CEM IV/A Plant A	CEM I Plant B	CEMII/B- P Plant C
Capacity	t/h	61	70	67
Fineness acc. to Blaine	cm²/g	4500	3500	4000
Spec. energy demand (mill)	kWh/t	15.9	17.2	17.5

Table 2: Operational data of MVR 3750 C-4 mill

Type	Unit	CEM II/B-P Plant D	CEM II/A-L Plant E	CEM III/A Plant E	CEM I Plant E
Capacity	t/h	157	111	85	90
Fineness acc. to Blaine	cm²/g	4580	3850	4820	3650
Spec. energy demand (mill)	kWh/t	14.8	20.1	20.3	21.3

❱ Table 1 gives an overview about production rates for different products ground in plants with MVR 2500 C-4 mills.

5 Operational results and digitization

Many MVR mills have been put into operation in recent years. Most cement manufacturers produce a wide range of products including the cement type CEM I and composite cements depending on available SCM. ❱ Table 2 lists the operational data of cements produced in MVR 3750 C-4 mills.

Figure 6: View of an MVR 5000 R-4 mill

Figure 7: Exemplary screenshot of data transmitted by GPpro system

Raw material grinding with MVR mills is also very common and proven in the field worldwide. Latest installations with MVR 5000 R-4 mills are located in Uzbekistan (◗ Fig. 6) and North Africa. One MVR 5000 R-4 mill produces a throughput of nearly 360 t/h of raw meal at 12 % residue on 90 micron with a specific power consumption of the mill of 9.5 kWh/t whereas another MVR 5000 R-4 mill grinds a raw material mix of better grindability to the same fineness that results in a throughput of 433 t/h at 7.0 kWh/t.

Industry 4.0 is also a driver for clients to cover operational support. One of the digital products from Gebr. Pfeiffer is GPlink which stores sensor data for data analysis and enables 24/7 access to data from mobile devices around the world. When transmitted to the company's service team a solid basis for support and rapid, targeted assistance is given. GPlink forms the basis for all other digital products.

The modular GPpro is the logical continuation of digitalisation. GPpro enables, for example, an advanced maintenance system with maintenance according to actual need and not according to fixed intervals. The system also includes additional sensors and offers modules for data analysis, reports, optimisation with the help of artificial intelligence and many other resource-saving optimisations such as dynamic water injection. With its finger on the pulse, the digital products are also constantly being developed in response to changing customer requirements. ◗ Fig. 7 shows a screenshot of charts of a small part of the process parameters; these charts are created individually based on transmitted data for process support.

The GPpro system has helped during the pandemic in 2020 to bring plants into operation. Commissioning was assisted from a distance where online meetings were also a big help. By providing additional pictures and movies from the plant sites the support could be targeted on specific topics.

6 Outlook

Gebr. Pfeiffer has been supplying clients with a wide range of vertical roller mills for decades. Since the first prototype installation in 2006, the MVR mill has been a well known and proven system, the series of MVR mills covers a wide range for small to large capacities, very fast time to the market with the ready2grind system and a versatile system for many feed material applications. The continuous product improvement with regard to sustainability, efficiency and digitization is oriented towards the client's needs. The Industry 4.0 trend gives an exciting approach to determine ideal conditions and settings for all applications in combination with artificial intelligence, where a huge potential is identified and the first results with an industrial mill have proved very promising. ◂

LITERATURE

[1] Schmalenberger, J.: ready2grind-the boom continues. CEMENT INTERNATIONAL 17 (2019) No. 1, pp. 36–40.