CEMENT INTERNATIONAL
PROCESSING PERFORMANCE APPLICATION

Reprint from / Sonderdruck aus: Issue No.: 4/2017, pp. 58–65

Case studies and operational results of modern MVR vertical roller mills

Fallstudien und Betriebsergebnisse von modernen MVR-Vertikal-Rollenmühlen

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Verlag Bau+Technik GmbH · Steinhof 39 · 40699 Erkrath · Tel.: +49 (0) 211 / 9 24 99-0

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SUMMARY

For decades vertical roller mills have been in use in the cement industry for the grinding of cement raw material and coal. Since the 1980's this mill type has also been used for combined or separate grinding of cement clinker and additives. During the last three decades, the number of installations for grinding cement and blastfurnace slag has increased remarkably. The trend in the cement industry is towards ever increasing capacities of individual grinding plants. Therefore, the need for high plant availability and an optimized maintenance concept is becoming more and more important. The MVR vertical roller mill with an installed power of up to 18 000 kW offered by the Gebr. Pfeiffer SE in Kaiserslautern is a tailor-made concept to fulfil these requirements. The first MVR mills were installed in Europe for cement raw material and cement grinding. These mills have been in operation since 2007 or 2008 respectively. Meanwhile the number of MVR mill installations has increased continuously. In this article, the operating data of several MVR mills installed worldwide will be discussed in detail.

ZUSAMMENFASSUNG

Vertikal-Rollenmühlen für die Zementrohmehlerzeugung und Kohlemahlung befinden sich in der Zementindustrie schon seit Jahrzehnten im Einsatz. Seit den 1980er Jahren findet dieser Mühlentyp auch für die gemeinsame oder getrennte Mahlung von Zementklinker und anderen Zementbestandteilen Anwendung. In den vergangenen drei Jahrzehnten ist die Zahl der Mühleninstallationen für die Mahlung von Zementklinker und Hüttensanden deutlich angestiegen. Dabei hält in der Zementindustrie der Trend nach großen Produktionseinheiten unvermindert an. Aus diesem Grund sind auch die Anforderungen an eine hohe Anlagenverfügbarkeit und optimierte Instandhaltungskonzepte immer wichtiger geworden. Die MVR-Vertikal-Rollenmühle, die von der Gebr. Pfeiffer SE aus Kaiserslautern, Deutschland, bis zu installierten Antriebsleistungen von 18 000 kW angeboten wird, versucht diese Anforderungen über maßgeschneiderte Konzepte zu erfüllen. Die ersten MVR-Mühlen sowohl für die Rohmehlerzeugung als auch für die Zementmahlung wurden in Europa installiert. Diese Mühlen befinden sich seit 2007 bzw. 2008 in Betrieb. Inzwischen hat sich jedoch die Zahl der im Betrieb befindlichen Mühlen kontinuierlich erhöht. In dem Beitrag werden von mehreren weltweit installierten MVR-Mühlen die erzielten Betriebsergebnisse mitgeteilt und im Detail diskutiert.

(English text supplied by the author)

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1 Introduction

The design features of the MVR vertical roller mill differ mainly from the well known MPS mill in the grinding element geometry, the roller suspension and the number of rollers. All machine parts that are relevant in terms of fluid dynamics, such as the hot gas channel, nozzle ring, SLS high-efficiency classifier and material feed, are of the same design as the parts that have proved successful in the well-established MPS mill.

The MVR mill is capable of producing high output rates of up to 1 000 t/h raw material. 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. The same applies to the so-called MultiDrive® design of the mill drive [1]: the mill is driven through a girth gear flanged to the grinding bowl by up to six actively redundant drive units with a total output of up to 18 000 kW. Each drive unit consists of an electric motor, a coupling and a gear. The grinding forces are transmitted to the foundation via a conventional plain bearing without placing any load on the gear units. Therefore, the gear units are not exposed to the grinding forces.

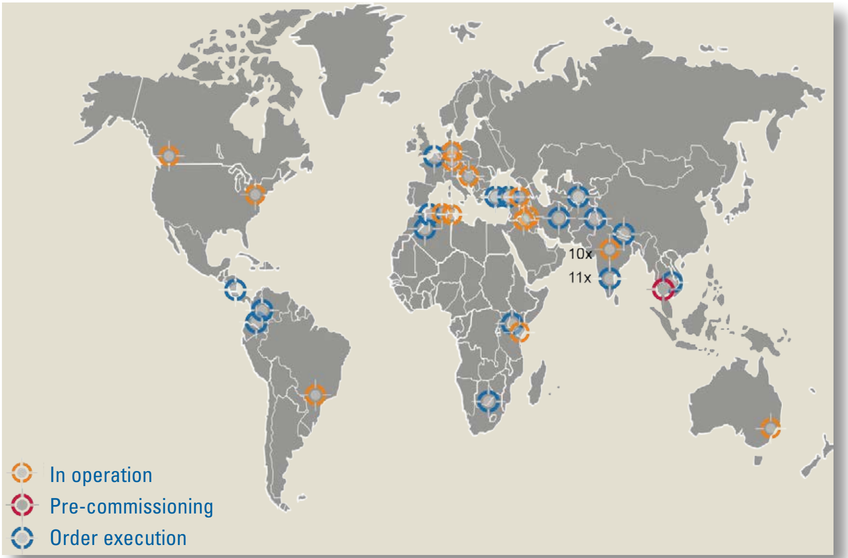

Figure 1: World map with MVR mill installations

Over the last years, many MPS and MVR mills have been put into operation all over the world. The first MVR mills were installed in Europe for cement and raw material grinding. These mills have been in operation since 2007 or 2008 respectively. Meanwhile more than 50 MVR mills are in operation or in order execution. The world map in ❱ Fig. 1 shows the geographic positions of MVR mill installations.

2 Cement raw material grinding with MVR mills

2.1 Case study: MVR mill MVR 5000 R-4

It was decided to increase the cement capacity of a plant in North America from 1.250 to 2.200 million t/a. For that requirement the plant equipment for pyro-process and grinding process had to be supplemented. To the existing ball mills for raw material grinding, an MVR mill with 5 m table diameter and four rollers was added. The existing kiln systems were partly modernized, one kiln line was replaced by a new line equipped with a five stage preheater calciner. To the existing ball mills for cement grinding, a 245 t/h vertical roller mill was added.

The rating of the MVR mill of the type MVR 5000 R-4 is based on grinding tests conducted at the test station of the Gebr. Pfeiffer SE in Germany. There are several pilot plants available with MPS and MVR mills which are operated in the same way as industrial plants. These pilot plants are used for the determination of raw material characteristics and project-related data, i.e. specific energy consumption, gas volume requirements, specific wear rate etc. The MVR 5000 R-4 mill in operation in North America is designed for a throughput rate of 340 t/h at less than 10 % R90 equivalent of less than 0.8 % R200. The grindability has been rated medium compared to other raw materials ground at the company's own test station. The technical details of the modular vertical roller mill are shown in ❱ Table 1.

Table 1: Technical details of the MVR 5000 R-4 mill

Designation	Unit	Technical data
Number of rollers	–	4
Roller diameter	mm	2 120
Roller wear part weight per roller	t	9
Roller wear part material	–	High chromium alloy cast iron
Installed drive power of the mill drive (planetary) the classifier drive the ID fan drive	 kW kW kW	 3 300 200 4 300

All dry and wet components such as limestone, sand, shale, iron are fed by belt conveyors through a rotary air lock into the mill (❱ Fig. 2). The rotary air lock is heated with hot gas to avoid clogging when feeding a combination of dry and wet components. The modular vertical roller mill is designed for the operation with an external material recirculation circuit. The mill is equipped with a water injection system. The finished raw meal is separated by a cyclone-system which removes more than

90 % of the dust raw meal. The rest of the raw meal is separated in the subsequently installed bag filter and also conveyed via air slides and a bucket elevator to the raw meal silo.

During commissioning the required throughput rates were achieved within a short time. All fineness figures also met the target values without any problems. ❱ Table 2 shows the guarantee figures compared to the achieved figures in the performance test. ❱ Fig. 3 shows a view of the modular MVR mill arrangement.

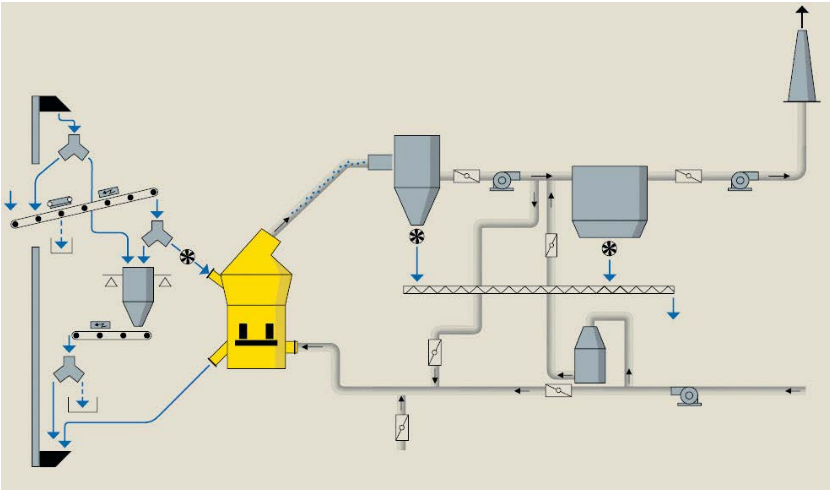

Figure 2: Flowsheet for cement raw material grinding with the MVR mill

2.2 Operational experience with MVR mills for raw material grinding

Over the last years, many modular vertical roller mills have been put into operation all over the world. For raw material grinding ❱ Table 3 shows the exemplary operational results for an MVR mill with a grinding table diameter of 6 m and six grinding rollers. ❱ Fig. 4 shows views of the modular MVR mill arrangement.

Figure 3: View of the MVR 5000 R-4 mill, North America

3 Cement grinding with MVR 6700 C-6 – a case study

The largest MVR mill for cement grinding is installed in the southeast of Brazil, close to the three most important cities in the country. The Barroso plant is equipped with two kiln lines and produces 3.6 million t/a of cement. With the installation in the year 2016 of an additional kiln capacity, a capacity of 2.6 million t/a cement was realized. The decision for the installation of an MVR mill was taken based on the lowest capital investment costs (CAPEX) for this grinding system. The grinding table of the MVR mill of the type MVR 6700 C-6 is driven by a MultiDrive® with six drive units, installed with a total power of 11 500 kW. The MultiDrive® is equipped with frequency converters so that the table speed can be adjusted to suit different finished

Table 2: Guaranteed vs. achieved results of the MVR 5000 R-4 mill

Designation	Unit	Technological figures	
		guaranteed	achieved
Feed moisture	%	≤ 4	4.1
Res. moisture	%	< 1	0.1
Product rate	t/h	340	350
Fineness R90	%	10.0	8.3
Spec. power consumption of the grinding table drive	kWh/t	8.3	7.8

Table 3: Operational results of the MVR 6000 R-6 mill for raw material grinding

Designation	Unit	MVR 6000 R-6 Algeria		MVR 6000 R-6 India	
		Guaranteed	Actual	Guaranteed	Actual
Feed moisture	%	≤ 6.5	1.7	≤ 5	1.15
Res. moisture	%	≤ 0.7	0.5	–	0.5
Product rate	t/h	680	692	500	545
Fineness R90	%	12.0	11.8	15.0	17.0
Spec. power consumption of the grinding table drive	kWh/t	8.5	8.0	12.1	10.8

Table 4: Operating data for the production of different slag cements and CEM I in the MVR 6700 C-6, installed in Brazil

Mix	Unit	40 mass % GBFS and 3 mass % limestone	34 mass % GBFS and 9.5 mass % limestone	20 mass % GBFS and 2 mass % limestone	0 mass % GBFS, 94 mass % clinker and 3 mass % limestone
Product rate	t/h	395	456	349	178
Spec. power consumption of the grinding table	kWh/t	28.5	21.9	27.3	41.4
Feed moisture	%	2.9	3.2	1.9	0.3
Fineness acc. to Blaine acc. to R38	 cm^2/g %	 4670 3.4	 4420 2.0 (R45)	 4850 2.1	 5500 0.9

product requirements. The MVR mill produces Portland slag cements with different granulated blastfurnace slag (GBFS) proportions of up to 50 mass %.

The civil works were started in March 2013 (❱ Fig. 5), mechanical and electrical installation (❱ Fig. 6) began nine months later and was completed by September 2015. Hot commissioning took place in April 2016. ❱ Fig. 7 shows the completed mill. ❱ Table 4 lists the operating data of the production of different slag cements, achieved during the performance test.

The flexibility of the equipment allows the production of a cement with a quality of CEM I with a fineness acc. to Blaine of up to 5500 cm^2/g, which was not defined in the project. The mill operates with a smooth level of vibration. During the commissioning and start-up no big issues were faced. The plant was running the mill without the supplier's supervisor after 79 h of commissioning. The flexibility of operation with less than six rollers or less than six drives is achieved due to the concept of active redundancy [1].

A second MVR mill of the type MVR 6700 C-6 is installed in Northern Africa. The mill has been in operation since April

Figure 4: MVR 6000 R-6 mill for raw material grinding, Algeria

Figure 5: Civil works at the Barroso plant in Brazil

Figure 6: Mechanical and electrical installation for the MVR 6700 C-6 mill at the Barroso plant

Figure 7: View of the completed MVR 6700 C-6 mill

Table 5: Operational data of the MVR 6700 C-6 mill, installed in Northern Africa

Operational data	Unit	Limestone cement	CEM I (OPC 2)	CEM I (OPC 1)
Limestone injection (feeding point at duct to filter)	%	18	0	0
Feed to mill (only clinker and gypsum)	t/h	280	240	345
Total output	t/h	330	240	345
Fineness acc. to Blaine acc. to R45	 cm²/g %	 4700 4.0	 4800 3.0 (R32)	 3875 2.5
Spec. power consumption of the grinding table drive	kWh/t	17.6	24.5	18.7

2016. The plant is producing limestone cement by separate grinding: in an MVR mill of the type MVR 6000 R-6, the limestone is ground, which is injected into the cement mill grinding circuit at the classifier outlet. The MVR 6700 C-6 mill grinds pure Portland cement to different fineness figures. The operating data are given in ❱ Table 5.

The mill has about 4000 operating hours to date. The main products which are sold for market reasons are limestone cements with different proportions of limestone. Due to the injection of limestone the finished product fineness gives a picture of the Blaine figure and residue of the mixed cement. Of the 4000 operating hours only less than 100 h with pure OPC were operated. This means that the mill had to be optimized and adjusted in a very short time for the high fineness figure of 4800 cm^2/g acc. to Blaine.

At the beginning of the commissioning several modifications to the classifier internals were conducted. This resulted in a better mill performance. The classifier will soon be equipped with a bigger drive system to take advantage of the full potential of the mill. This means that the mill can be used as a test system e.g. for grinding to an even higher fineness of a Portland cement with figures of more than 5300 cm^2/g acc. to Blaine.

4 Outlook

MVR and MPS mills are very flexible for grinding feed materials such as clinker, limestone, 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.

The use of GBFS and other composites for cement is increasing worldwide for producing cements and concrete. Therefore, the issue for inter-grinding or separate grinding is still under discussion. When intergrinding clinker and GBFS the finer and most reactive fractions do not contain any or only very small proportions of GBFS. The decision for this way of grinding has to be taken carefully. When comparing e.g. GBFS from different sources the properties can vary within a wide range and therefore, a tailor-made production mode with specific fineness of finished product is necessary to get the required final product. Many plants have decided for separate grinding such as for example in Australia, where an MVR mill of the type MVR 6000 C-6 has been producing GGBFS and CEM I since 2014.

An MVR mill of the type MVR 5300 C-6 will be installed in Belgium in the near future; this mill is planned to produce slag cements by inter-grinding as well as a cement of the quality CEM I and GGBFS as single products for subsequent mixing. In Cambodia several mills are in pre-commissioning: an MVR mill of the type MVR 5000 R-4 for raw material grinding with an output of 410 t/h at a fineness, according to an R90 figure, of 15 %, and an MVR 6000 C-6 mill for composite cement production with an output of 300 t/h at a fineness, according to an R36 figure, of 12 %. In Turkey an MVR mill of the type MVR 5000 R-4 passed the acceptance test in July 2017 with an output of more than 200 t/h at a fineness, according to an R90 figure, of 12 % and a specific power consumption of the main drives (mill, classifier, fan) of less than 15 kWh/t.

The MVR mill, available on the market for the past ten years, is the right choice for the handling of versatile feed components. In combination with an increased plant availability and ease of maintenance, the MVR mill offers a low specific electric and thermal energy consumption.

LITERATURE

[1] Hoffmann, D.; Schmitt, L.: The MultiDrive – a safeguard against total failure. CEMENT INTERNATIONAL 15 (2017) No. 2, pp. 48–56.