M. Baechler, FLSmidth Maag Gear AG, Winterthur, Switzerland

SUMMARY

Today, vertical roller mills (VRMs) with highest installed drive power are used in the cement and slag grinding processes and up to now, they did not reach their maximum throughput rates. By the end of the past decade, the power increase reached the limits of the conventional drive units. Mainly the bevel gear stage, responsible for changing the direction of rotation axis, reached physical dimensions where manufacturing is getting difficult and costly. This challenge led to new drive systems. Analysing today's available drive systems for large and very large VRM, a separation into two main categories is obvious: modular drive systems, where two or more electrical motors provide the required drive power and integrated drive systems, where the bevel gear stage is replaced by one vertical electrical motor. FLSmidth MAAG Gear has recently introduced their new products for VRM drives: MAAG™ MAX Drive belongs to the modular drive systems, while MAAG™ CEM Drive is the only available integrated drive system on the market. The modular concept of MAX Drive with its two drive modules relies on known motor and gear technologies. The torque split in each drive module guarantees reaching highest power for cement and slag grinding and the height of the central unit allows reducing the mill height to an absolute minimum. Compared to other available modular drive systems, MAX Drive has only two motors and therefore the connection to the power grid and the monitoring does not increase the complexity unnecessarily. The CEM drive combines proven gear technology with advanced motor development which results in a flexible drive system for VRMs within same dimension as conventional gearboxes. This again allows the cement producer to standardise mill drive units of new and existing plants. The high performance electrical motor, driven by a state-of-the-art frequency converter, drives any vertical roller mill up to the highest required power demands.

ZUSAMMENFASSUNG

Heute werden Vertikal-Rollenmühlen (VRM) mit den höchsten installierten Antriebsleistungen für die Zement- und Hüttensandmahlung eingesetzt, die allerdings bislang noch nicht die maximal möglichen Durchsätze erreicht haben. Am Ende des vergangenen Jahrzehnts erreichten die konventionellen Antriebe ihre Leistungsgrenze. Vor allem die Kegelradstufe, verantwortlich für die Drehrichtungsänderung, würde physikalisch gesehen Dimensionen erreichen, die die Fertigung schwierig und teuer machen würde. Diese Herausforderung führte zu neuen Antriebssystemen. Bei der Analyse der verfügbaren Antriebssysteme für große und sehr große VRM lassen sich zwei Hauptkategorien feststellen: modulare Antriebssysteme, bei denen zwei oder mehr Elektromotoren die erforderliche Antriebsleistung liefern und integrierte Antriebssysteme, bei denen die Kegelradstufe durch einen vertikalen Elektromotor ersetzt wird. FLSmidth MAAG Gear hat kürzlich seine neuen Produkte für VRM-Antriebe vorgestellt: MAAG™ MAX Drive gehört zu den modularen Antriebssystemen, während MAAG™ CEM Drive das einzige integrierte Antriebssystem auf dem Markt ist. Das modulare Konzept des MAX Drive mit seinen zwei Antriebsmodulen basiert auf bekannten Motor- und Getriebetechnologien. Die Drehmomentaufteilung auf einzelne Antriebsmodule garantiert höchste Leistung für die Zement- und Hüttensandmahlung, und die Höhe der Zentraleinheit ermöglicht es, die Bauhöhe der Mühle auf ein Minimum zu reduzieren. Im Vergleich zu anderen modularen Antriebssystemen verfügt MAX Drive nur über zwei Motoren, wobei die Verbindungen zum Stromnetz und zum Monitoringsystem die Komplexität kaum erhöhen. Der CEM drive kombiniert bewährte Getriebetechnologie mit fortschrittlicher Motorenentwicklung und führt zu einem flexiblen Antriebssystem für VRM in der gleichen Dimension herkömmlicher Getriebe. Das ermöglicht wiederum dem Zementhersteller, die Mühlenantriebe neuer und bestehender Anlagen zu standardisieren. Der leistungsstarke Elektromotor, ausgerüstet mit einem Frequenzumrichter der neuesten Generation, treibt jede Vertikal-Rollenmühle mit dem höchsten erforderlichen Leistungsbedarf an.

(English text supplied the author)

The future of vertical roller mill drive systems

Die Zukunft der Antriebssysteme für Vertikal-Rollenmühlen

1 Introduction

While vertical roller mills have been widely established for many years now for raw material and coal grinding, the market share in cement and slag grinding has steadily increased over the past decade. The acceptance of the vertical roller mill in the cement grinding process is related to the high efficiency and to the fact that all process steps, such as drying, grinding, material conveying and separation, are combined in one unit, simplifying the plant layout. Vertical roller mills also offer the advantage of high and very high throughput rates at identical material quality compared to other grinding systems like horizontal mills or high-pressure grinding rolls.

Today, vertical roller mills with the highest installed drive power are used in the cement and slag grinding processes and up to now, they did not as yet reach their maximum throughput rates. The increasing number of vertical roller mills in cement grinding and the widespread use in raw material grinding leads to another advantage of this mill system. Because of weight-reduction during the pyro-process and the different grindabilty of raw materials and clinker, it is possible to erect production lines with only one large raw mill supplying material for two cement mills of identical size. The results are standardized production lines with common parts, bringing the advantage of economies of scale together with high efficiency and savings from common parts as well as reduced spare part inventory for the cement producer. With the latest introduction of the OK mill for raw material grinding, FLSmidth is pushing this modularization to a new level. However, the increasing mill drive power challenges the drive system and leads to new drive systems. ❱ Fig. 1 shows one of the world's largest vertical roller mills, the OK Mill 54-6, equipped with a conventional gear box with an installed power of 8650 kW.

Figure 1: View of one of the largest vertical roller mills, the OK mill 54-6 for raw material grinding, equipped with a conventional gearbox with an installed power of 8650 kW

2 Concept and design of the drive systems

The constant increase in the grinding capacity of vertical roller mills has defined the evolution of the required drive system. From the very beginning, conventional drive systems consisted of one stand-alone horizontal electrical motor, providing the necessary torque and a gearbox, reducing input speed to mill table speed and changing the rotation axis from the horizontal to the vertical direction. By the end of the past decade, the power increase reached the limits of the above-mentioned conventional drive units. Mainly the bevel gear stage, responsible for changing the direction of rotation axis, reached physical dimensions where manufacturing is becoming difficult and costly. Gear units with a design power of up to 9000 kW and a gear ratio of 50 are still possible to realize, but require customized design for each application. The design is not only focused on the bevel gear stage but on the entire gearbox, its bearing arrangement and casing stiffness influencing the dynamic behaviour of the gearbox.

Analysing today's available drive systems for large and very large vertical roller mills, a separation into two main categories is obvious:

- ❱ Modular drive systems, where two or more electrical motors provide the required drive power.
- ❱ Integrated drive systems, where the bevel gear stage is replaced by one vertical electrical motor.

FLSmidth MAAG Gear AG has recently introduced their new vertical roller mill drives: The MAAG™ MAX Drive belongs to the modular drive systems, while the MAAG™ CEM Drive is the only available integrated drive system on the market.

2.1 MAX Drive

The well-known lateral drive for vertical roller mills served as basis for the development of the MAX Drive concept. A compact gearbox splitting the drive torque, provided by an electrical motor, for two output-pinions, which mesh with the girth gear mounted around the mill shell.

MAX Drive, following the concept of lateral drives, provides the required drive power by two drive modules, each connected to a common girth gear (❱ Fig. 2). A vertical asynchronous motor is directly flanged to the casing of each drive module. The torque generated by this motor is divided into two parallel helical gear trains, each meshing with a self-aligning pinion into the central girth gear. On top of the intermediate shaft, a highly flexible coupling is located. This coupling fulfils three main tasks. On the one hand, it ensures an equal load distribution between the two gear trains and on the other hand, the correct timing between the two output-pinions and the central girth gear can be adjusted with this coupling. Finally, thanks to the damping of torque peaks and adaptable stiffness, it guaranties smooth operating behaviour. The central unit serves also as a support for the grinding table. Grinding loads are transmitted via a hydraulic thrust bearing

PROCESSING

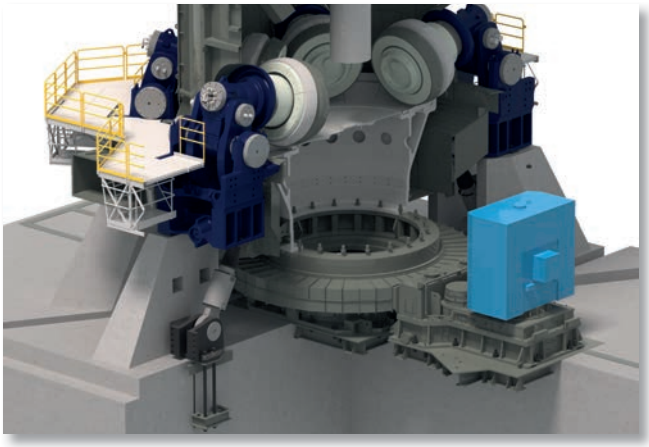

Figure 2: MAX Drive installed under an OK Mill for cement grinding

directly into the foundation without affecting tooth contacts in the drive units. Compared to conventional gearboxes the central unit of the MAX Drive requires less vertical space. The entire mill installation can be reduced in height.

2.2 CEM Drive

The CEM Drive is a real novelty in cement production. Contrary to modular drive systems, the concept of the CEM Drive is built to use only one main motor (❯ Fig. 3). This motor is vertically oriented, integrated in the gear casing and replaces the bevel gear stage. On top of the motor, a double planetary gear stage provides the required speed reduction and torque increase. Together with the hydraulic thrust bearing it is one to one the identical design as in conventional gearboxes. The motor is not only designed to fit into the gear casing, providing the same outer dimension as conventional gearboxes, but it is also made for highest efficiency and optimum operation characteristics.

The result is a synchronous motor with permanent magnet-exited rotor, including a space and energy saving single coil stator. The central element of this unique motor is the direct fluid-cooled stator. Gear lubrication oil is used as the cooling media, which is routed directly through the stator body to evacuate heat losses at the place of origin. The second source of losses, the rotor, is cooled by an internal airflow. The shaft-mounted van generates an air current flowing along the gap between rotor and stator and cooling the magnets mounted on the rotor body. The hot air leaves the rotor at the top and is forced to flow along the back of the stator down to the bottom of the motor casing. As the stator is directly cooled by lubrication oil, it also serves as a heat exchanger for the internal airflow. Once the cold air arrives at the bottom of the motor casing, the ventilator aspirates it again into the rotor for cooling.

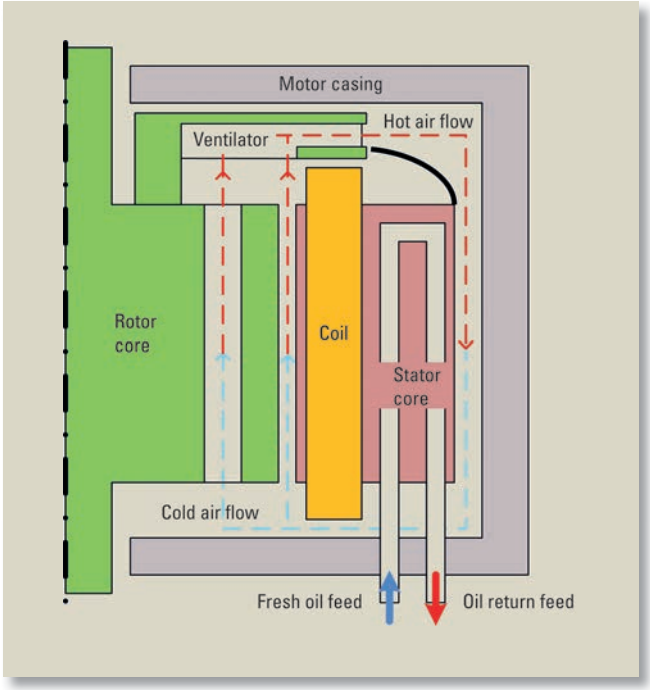

Figure 3: Schematic air flow inside the motor

The variable frequency converter, feeding the motor, allows operation of the mill at optimum process conditions. Especially when there are several mills for raw material and cement grinding of similar dimensions and power ranges, the CEM Drive is able to operate each mill at the required speed without changing internal toothed parts. It supports the effort of modularization of the equipment in the cement production plant. ❯ Fig. 4 shows the first installed CEM Drive under a vertical roller mill for raw material grinding.

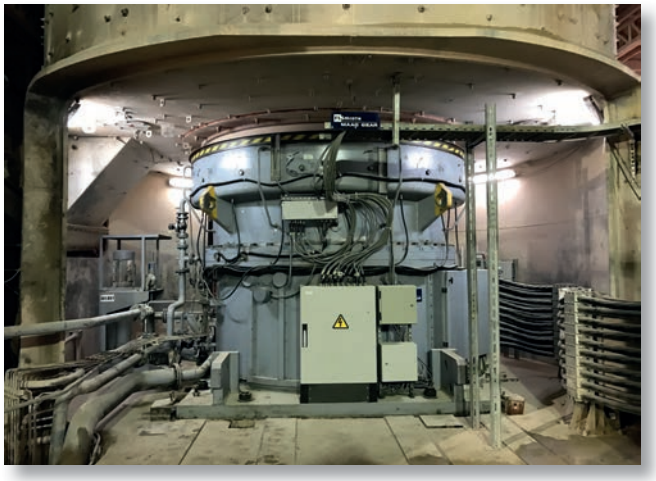

Figure 4: First installation of a CEM Drive under a vertical roller mill for raw material grinding

3 Product characteristics

The modular concept of the MAX Drive with its two drive modules relies on known motor and gear technologies. The torque split in each drive module guarantees reaching the highest power for cement and slag grinding and the height of the central unit allows reduction of the mill height to a minimum. Compared to other available modular drive systems, the MAX Drive has only two motors and therefore the connection to the power grid and the monitoring does not increase the complexity unnecessarily.

Mechatronic units are already established in many industries and applications, in cement production the integrated motor concept of the CEM Drive is still a novelty. From the straightforward purchase process to small mill foundation up to the simple setup and commissioning, its potential is immense. The combination of proven gear technology with advanced motor development results in a highly flexible drive system for vertical roller mills within the same dimensions as conventional gearboxes. This again assists the cement producer in standardizing the mill drive units of new and existing plants. The high performance of the electrical motor in connection with the use of a state-of-the-art frequency converter, drives any vertical roller mill up to the highest required power demands. ◀