Vertical Versatility

Gerhard Salewski, Loesche GmbH, Germany, provides details of the development of Loesche vertical roller mills for large capacity grinding.

Introduction

Vertical roller mills, traditionally used in raw material grinding, are also used for cement and slag grinding. According to Loesche's module principle, the well-proven elements of the raw material mills are adopted in the cement and slag grinding mills. This module system allows the design of 2-, 3-, 4- or 6-roller mills with the same modules used for raw material, as well as cement and slag grinding. Due to the fact that cement and slag are ground to a higher fineness, Loesche has developed a technology with differently sized rollers for influencing the material flow over the table.[1]

Figure 1 shows the interrelationship of roller arrangement and capacity with economical specific costs for mills with 2, 3, 4, or 6 rollers. If the system is used above its optimum the efficiency will decrease, the handling will be much more complicated, or the specific costs will increase. For a capacity of 550 tph of finished raw material, a Loesche 3 roller mill would have to be equipped with rollers of 3150 mm diameter, whereas a Loesche 4 roller mill would only require a diameter of 2360 mm. The mass of the larger roller is approximately 80% higher than the smaller one and correspondingly the dynamic forces and the costs are higher. By retaining the smaller roller diameter, the modular concept is implemented. With the demand for increased production rates at low specific energy consumption, Loesche has increased the number of individually arranged rollers following the module concept.

The module concept for cement grinding

Generally, the module concept for raw material grinding can be adapted for all other applications, including cement grinding, the grinding of clinker and clinker additives. Nevertheless, when comparing cement and raw material grinding there are five significant differ-

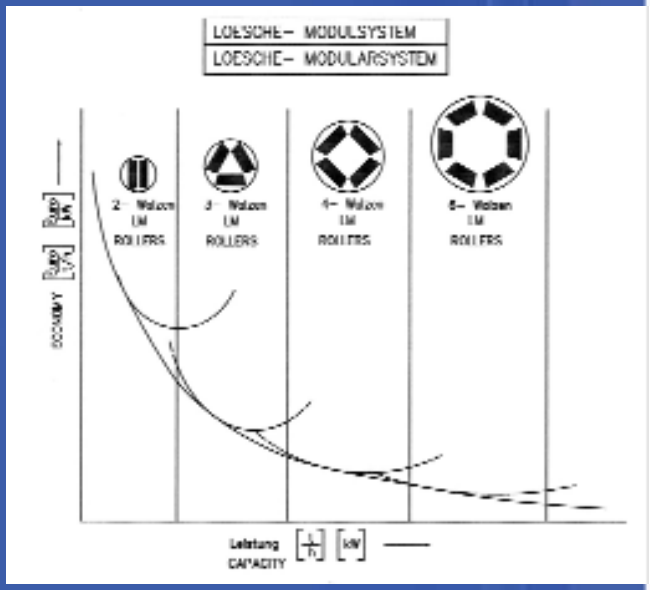

Figure 1. Economy and capacity of vertical roller mills (VRMs).

Figure 2. Master roller and support roller in a LM 35.2+2.

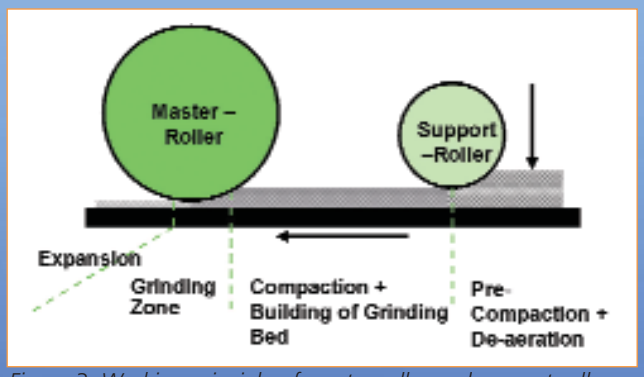

Figure 3. Working principle of master roller and support roller.

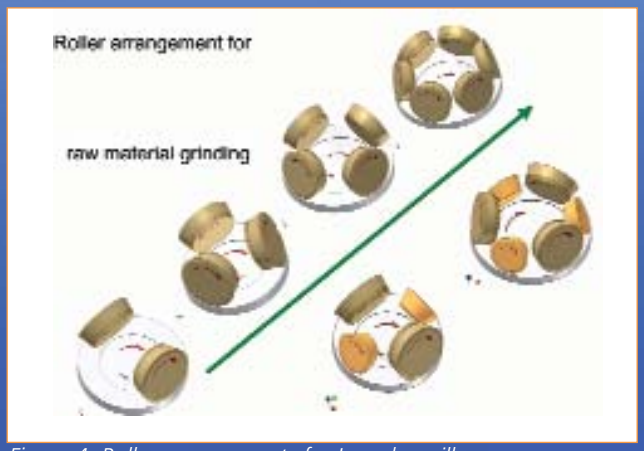

Figure 4. Roller arrangements for Loesche mills.

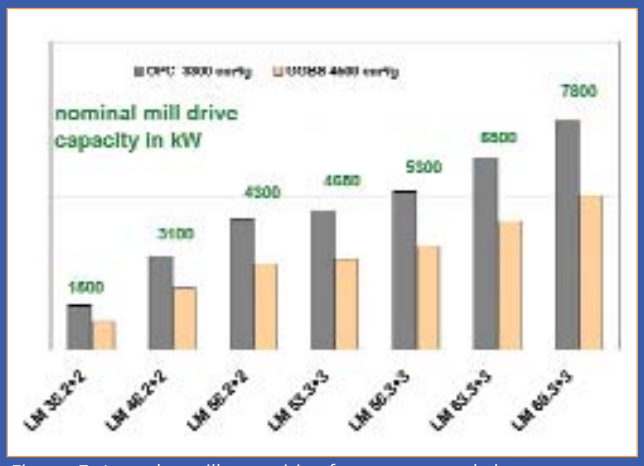

Figure 5. Loesche mill capacities for cement and slag.

ences:

- Cement is ground to a Blaine fineness of 3000 - 4500 cm^2/g, corresponding to <15% R0.045 mm in the case of cements and <15% R0.090 mm for raw material.
- The quality requirements of cement properties are much stricter than those for raw materials and the slope of the particle size distribution must be within a certain limit.
- The feed moisture of cement is almost zero, while raw materials have a higher feed moisture, even up to 25%.
- The high finenesses of cement interfere with the grinding process through fluidisation of the grinding bed.
- As a further effect of higher fineness, the internal circulation in the mill increases, therefore it is more difficult to form a grinding bed for cement grinding than raw material grinding.

The main requirement in grinding cement and cement additives in VRMs is the stabilisation of the grinding bed. Compared to the grinding of raw materials, the internal circulation between the grinding table and the classifier is substantially higher. This leads to a large amount of fine-grained and highly aerated particles on the grinding table. With a well stabilised grinding bed mill vibrations are avoided and mill operation is smooth and efficient.[2]

After a period of intensive research and development work using CFD simulation, Loesche introduced the modified module concept of raw material grinding for cement. The preparation and comminution of the grinding bed are undertaken by separate elements, a patented solution. Two of the four full size grinding rollers of the original four-roller mill have been replaced by smaller rollers. Figure 2 shows the rollers of an LM 35.2+2 mill with two pairs of rollers. The larger roller (master roller) is for the material grinding, while the smaller roller (support roller) is used for the material preparation.

Figure 3 illustrates how the material bed on the grinding table is prepared by the support roller before it is ground by the master roller. The movement of the grinding table is from the right to the left. The material on the grinding table is pre-compacted and de-aerated by the support roller so that a material bed is formed under a low pressure. The master roller finally comminutes the material under a high grinding pressure and the material expands and is mixed with fresh material. This mixed material is transported to the next pair of rollers, where another preparation and grinding cycle begins. The support rollers are positioned at a certain level above the grinding table by hydraulic cylinders. As only small forces are necessary for preparation with the support rollers, a simpler design than that of the master rollers could be realised.

Figure 4 illustrates the different arrangements of rollers. While the capacities for raw material grinding are fulfilled by 2, 3, 4 and 6 rollers, for cement grinding and slag grinding the 2+2 and 3+3 arrangements are available.[3] The field proven module of the largest LM in operation (LM 63.4 for cement raw material grinding) is also used for master rollers in a 2+2 arrangement (LM 56.2+2) and 3+3 arrangement (LM 69.3+3). Figure 5 shows the nominal capacities and mill sizes for cement and slag grinding. In total, seven different sizes are available with nominal capacities ranging from 60 tph - 300 tph for cement and 45 tph - 200 tph for slag. Smaller capacities are achieved with the 2+2 concept, larger capacities are achieved with the 3+3 concept. The nominal mill drive

ranges from 1500 kW up to 7800 kW.[4]

Plant concepts for VRMs and advances

Grinding plants using vertical roller mills for the grinding of cement and cement additives are distinguished, above all, by their simple arrangement (Figure 6). Feed materials are transported from the storage bins via belt feeders and rotary air looks into the mill. In the mill the material is ground, classified and when necessary dried by exhaust gas or an auxiliary hot gas generator. Coarse material from the grinding table is returned via the reject transport system to the feed material. The finished product from the integrated high-efficiency classifier leaves the mill in a gas stream and is separated in a down-stream bag filter. The fan behind the filter provides the necessary draft.

As Loesche mills are operated as finish grinding systems, no intermediate transport of semi-finished products and no additional classifier are required. The specific power consumption is, thus, kept to a minimum of 15 - 35 kWh/t, depending on the cement products and finenesses, and the costs for electrical power and maintenance are kept at a remarkably low level. With compact filters and modified ductwork, approximately 30 - 40% of the steel structure (compared to conventional ball mills systems) can be saved.[4] Due to the low noise emissions from VRM plants and minimum precautions against wind and rain, a closed building is not necessary, even at unfavourable plant locations.

Ball mills in conventional cement grinding plants are usually optimised for only one or two feed materials. Contrary to that, Loesche mills are able to grind a variety of cements, blended cements and slag products with different product specifications in alternate mode. Accordingly, a number of LM mills are used for separate grinding of clinker, slag, pozzolana and limestone or inter-grinding a combination thereof. Product changes can be carried out within approximately 30 - 45 minutes from the control room without stopping the mill.[5] The operational parameters can easily be adapted, as in LM mills the grinding pressure can be adjusted via the hydropneumatic spring system and the particle size can be adjusted by the integrated high-efficiency classifier. The excellent drying capability allows moisture contents of 15% and more in the mill feed. The amount of intermediate products from the transition period is extremely small and no reject silo is required.

When VRMs have been introduced for cement grinding there have been concerns about the cement quality and especially steep particle size distribution curves. Today, it is the common understanding that in VRMs particle size distributions can be generated which approximate that from ball mill circuits or have even more favourable distributions.[6] However, to achieve the desired particle size distribution (Figure 7) with slope 'n' of the particle size distribution and the position parameter 'x' variable adjustments can be made, such as higher grinding pressures, change of grinding bed thickness, variation in grinding table speed and working pressure.

Water demand and setting behaviour are additionally influenced by the dehydration of gypsum added to the cement and prehydration of clinker minerals, which are influenced by the temperature in the mill, the retention time of the material and the gas conditions inside the mill. As in VRMs, less grinding energy is dissipated, so the material will not be heated up as in a ball mill, leading to a lower degree of dehydration of the gypsum. Accordingly, when no heat can be added to the mill system, an optimisation of the sulphate carrier becomes necessary. A water injection in the mill has the similar effect as grinding aids, which can become necessary when products are ground to higher finenesses.

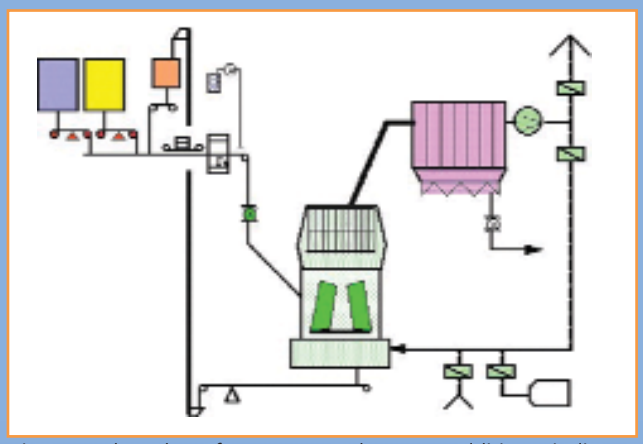

Figure 6. Flow sheet for cement and cement additive grinding.

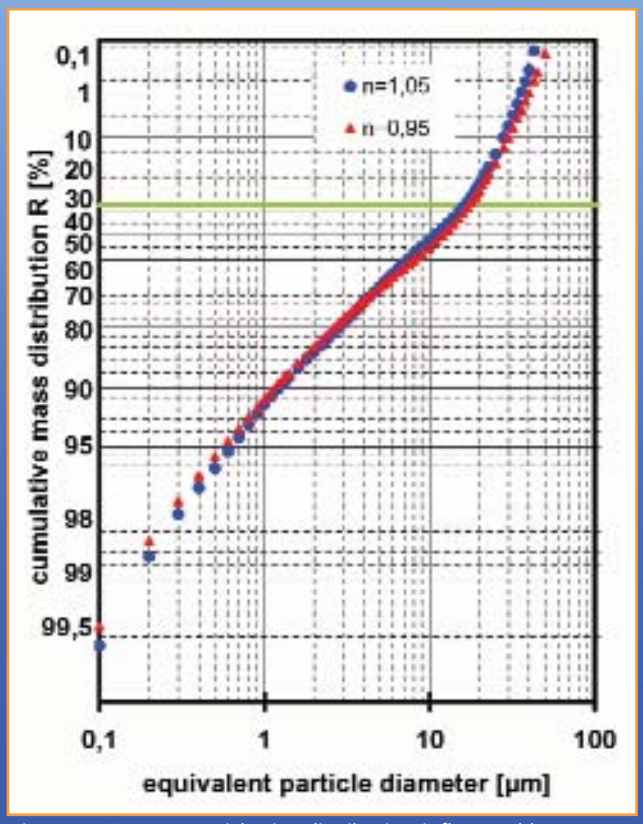

Figure 7. Cement particle size distribution influenced by VRMs.

Recent examples

As of May 2005, a total of 56 LM mills for the grinding of clinker, slag and blended cements have been sold, of which 23 are for the grinding of clinker and blended cements and 33 are for the grinding of slag and slag cements with different finenesses. About 35 mills are already in operation, the first one - an LM 46.2+2- since 1995 at Pu-Shin in Taiwan. The following concerns the latest plants to enter a first production phase or become operational.

Holcim Maroc

The company has supplied an LM 46.2+2 (Figure 9) to the Ras-El-Ma grinding plant of Holcim Maroc. The mill has been in operation since the end of 2004 and is producing one ordinary Portland cement and two basic Portland composite cements. CPA 55 is the ordinary Portland cement with a fineness of 4450 cm^2/g (Blaine), CPJ 35 is a Portland limestone cement with 28% limestone and CPJ 45 with 14% limestone. The guaranteed mill throughput is 55 tph and 115 tph respectively, which were achieved even at higher finenesses. A 2400 kW drive is installed for the mill.

Holcim Vietnam

Holcim awarded Loesche an order for the supply of a LM 56.2+2 for their new Thi Vai cement grinding plant (Figure 8), which is approximately 80 km from Ho Chi Min City. The plant is in operation and has been designed for an annual throughput of 1.3 million t. The guarantee figures are for the grinding of two specific cement products, each for 180 tph. Composition of type PCB is with 8% limestone and 16% Pozzolan at 8% R0.045 mm, and type SB consists of 8% limestone. The guaranteed throughput can be achieved without any grinding aid or injection of water. A 4000 kW drive is installed for the mill. The specific power consumption for the PCB 40 at 4500 cm^2/g is approximately 20 kWh/t.

Orissa Cement India

Orissa Cement has ordered for the Rajgangpur 3 cement plant a 250 tph cement mill - the third vertical roller mill for cement and slag grinding - from Loesche. The new LM 56.3+3 (Figure 10) is under construction and will start production in August 2005. The mill is capable of grinding Portland cement, Portland slag cement, Portland fly-ash cement and slag within a range of 3300 to 5500 cm^2/g (Blaine) with capacities of 88 tph to 178 tph. The guarantee figure for OPC (4500 cm^2/g Blaine) is 134 tph. The mill is equipped with 6 rollers (3+3 technology) and has a drive capacity of 5300 kW. A special advantage for Orissa Cement is that the sizes and design of the mill components are identical to the components of the two LM 46.2+2 mills that have been successfully operating for years.

Outlook

Loesche offers taylor-made solutions for all kinds of grinding operations in cement plants. The implementation of the module system has been the key to success in the production of cement, as well as slag products. With the 3+3 technology Loesche is prepared to replace 2 to 3 ball mills in cement grinding plants with only one vertical roller mill. The high availability, the operational reliability and the high energy efficiency are characteristic features of these mills. With the considerable savings of energy consumption compared to ball mills, the Loesche mill provides the cement industry with a very versatile tool for meeting the demands of the markets. ◆

Figure 8. LM 56.2+2 in Thi Vai plant of Holcim Vietnam.

Figure 9. LM 46.2+2 in Ras-El-Ma plant of Holcim Maroc.

Figure 10. LM 56.3+3 in Rajgangpur plant of Orissa Cement, India.

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