SOURCING *sustainable* SOLUTIONS

Dr. Caroline Woywadt, Gebr. Pfeiffer, Germany, weighs up some of the challenges facing the comminution sector and spotlights vertical roller mill technology as a possible solution.

Global mineral demand is increasing, driven by energy transition and CO_2 reduction goals. Rising power costs, paired with declining ore grades and more difficult ores, require changes in equipment selection.[1] As comminution remains one of the most energy-intensive stages in mineral processing, energy-efficient systems must be chosen. Water consumption also features heavily in the discussion for enhanced sustainability.

A well-known dry grinding system is the vertical roller mill (VRM), which provides substantial benefit regarding energy savings. Compared to traditional tumbling mill systems in the mining industry, the VRM system's energy consumption is approximately 30 – 40 % lower. There is a need for a systematic approach, that is to evaluate not only machines, but to understand how each equipment technology can be integrated into the complete flowsheet.[2]

As the VRM is a new technology in the mining industry, but well known and proven in many other industries, this article describes the special features of the VRM as an air-swept system. A comparison with high-pressure grinding rolls (HPGR) combined with air classification will also be presented,

in addition to a discussion of the challenges of grinding part and mill internal wear.

The air swept vertical roller mill and pressure drop

Vertical roller mills combine grinding, drying, and classification in a single machine. The grinding plant operates under negative pressure, i.e. a system fan is installed downstream of the cyclone or bag filter for dust collection. Figure 1 shows a plant with a bag filter (right) and a cyclone system (left) for particle/dust separation. To obtain optimum adjustment flexibility, the system fan is equipped with a variable-speed drive using a frequency converter. The gas flow ensures the material transport; gas volume and gas velocities produce a relatively high pressure loss, and therefore the system has a higher mill fan power consumption compared to dry grinding ball mill systems.[3]

Optimisation of the mill fan power consumption includes several topics: leakage points must be checked and eliminated. All ducts, cyclones, and dust collectors must be checked, especially all doors. The system gas flow will increase by closing all leakages. With the elimination of the leakage, the fans will be able to draw more gas through the mill. The nozzle ring velocity must be reduced or optimised to reduce pressure drop and avoid too much reject material.

The pressure drop of the vertical roller mill results from the pressure drop in the hot gas duct and the pressure drop in the nozzle ring. The difference between pressure at classifier outlet and pressure at mill inlet results in the total pressure drop of mill and classifier. Figure 2 shows the pressure profile for the mill and classifier. Some equipment suppliers do have the split in pressure sensors for classifier and mill, others do not. The determination of pressure drop for the mill itself and the classifier separately provides a better picture for understanding the optimisation potential of the air swept system.

Figure 1. Plants with MVR 6000 R-6 mills: Bag filter system (right), cyclone dust separation (left).

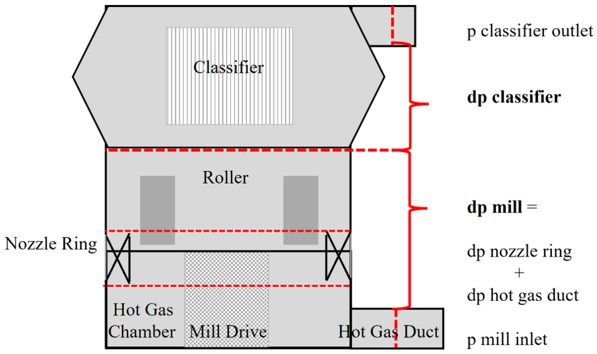

Figure 2. Pressure drop in the vertical roller mill (type MVR).

Table 1. Comparison MVR vs HPGR for raw material grinding, India. SPC = specific power consumption

Plant	MVR 6000 R-6	HPGR finish mode
Circuit	Single VRM compact circuit	#3 HPGR split grinding circuit
Contractual capacity	620 tph @ 98% P212µm	3 x 275 tph @ 98.5% P212µm
Present capacity	735 tph	3 x 255 tph
Fineness (approximate)	97% P212µm	96% P212 µm
SPC at meter		
Mill main drive	8.40 kWh/t	8.47 kWh/t
Classifier	0.18 kWh/t	0.10 kWh/t
Fan	5.44 kWh/t	5.20 kWh/t
Bucket elevator recirculation	0.01 kWh/t	0.30 kWh/t
Total	14.03 kWh/t	14.07 kWh/t

Comparison of MVR-R mill to HPGR systems – knowledge transfer from other industries

HPGR systems have been in operation for many years in the cement industry as well. The efficiency of the HPGR is highly dependent on the characteristics of the material it is working with. Very moist materials are not a good fit, for example, and likewise soft materials will not return the same efficiency advantage. Fineness is also an issue, since HPGR is not the most suitable system for grinding very fine materials. For cement raw material grinding, VRM and HPGR are in operation in many plants. The fan power consumption is always under discussion when comparing both systems. Other key features – e.g. civil cost, layout of the circuit, etc. – are also very important for evaluating the best technology for a plant. The VRM circuit has lower civil cost than the HPGR circuit in terms of concrete volume and footprint, and the equipment CAPEX is lower than that of HPGR in finish mode. The VRM accepts a bigger feed size, therefore an additional crusher stage can be avoided. The VRM circuit is very compact, needs less external equipment, and has an easy layout. The MVR mill has an in-built redundancy at the roller level, and can operate with rollers under maintenance, e.g. an MVR 6000 R-6 can operate with four rollers when two rollers are swung out.

Table 1 shows the comparison of two operating mill systems for raw material grinding in India. Both units are in the same geographical region where the same limestone grindability is used. The mill circuit auxiliary power is not included as it depends on the site layout and most probably will remain the same for both cases. The total circuit power for both plants is reported to be 16.5 kWh/t. The HPGR circuit is operating at less capacity than guaranteed contractual capacity, even with coarser product fineness. The difference in total power consumption for the main equipment is on the same level.[3] This concludes that the MVR mill is very competitive to the HPGR system. That applies not only to the cement raw material grinding but also to other materials to be ground, such as ores.

Wear of grinding parts and mill internals

While dry grinding in VRM offers advantages in reducing energy consumption, challenges remain for wear-resistant materials – most ores are high in abrasion compared to other industries where VRMs are operated in thousands of installations.

In Gebr. Pfeiffer test centres, tests for abrasive wear of grinding parts and erosive wear for mill internals are established. To determine the abrasive wear of grinding parts, the roller tyres and table liner are weighed before and after each test in the pilot plant, as taking the weight of the complete set into account increases the accuracy of the determined wear rate.[4] The calculation of the specific wear rate in g/t by weight loss of grinding parts and ground material quantity during the test gives a figure for the lifetime of grinding parts in the industrial plant. Abrasive wear for the ores investigated so far depends strongly on the ore body and the mineralogy of the material to be ground. This wear behaviour must be answered by wear protection materials for the grinding parts in the vertical roller mill that can achieve a high lifetime. In combination with maintenance concepts for roller exchange those wear protection materials are under development in R&D at Gebr. Pfeiffer. Those developments will be reported due to IP reasons at a later point in time.

Erosive wear is determined by Gebr. Pfeiffer in a custom, self-developed wear test apparatus. The value determined in the test provides a relative classification of the various ground materials regarding the wear intensity.[4] Erosive wear for the investigated ores is in the range of cement and blast furnace slags. These cementitious materials are well known and have been ground for many decades in industrial vertical roller mills. Wear protection for the mill internals, the classifier, and ducting in the grinding plant for these applications can be easily adapted to the mining industry.

Conclusion

Reducing the carbon footprint is a challenging situation for all industries. The performance of a VRM is defined by a required throughput at a required fineness paired with a low specific thermal and electric energy consumption.

The MVR mill by Gebr. Pfeiffer for dry grinding applications is a proven technology with many decades in industry applications for grinding of hard to medium-hard materials. This flexible equipment reduces energy consumption, enhancing sustainability, and simultaneously improving the circuit's overall emissions profile in ore processing. Depending on the ore body, the grind size adjusted for flotation could reduce further grinding energy, produce coarser tailings, and decrease the footprint of flotation circuit and solid-liquid separation.

The grinding plant with the MVR mill needs a small footprint. Due to dry operation, the milled material can be stored in silos before further processing downstream. Therefore, the grinding unit is de-coupled from downstream processing systems and gives an additional degree of freedom in process application. Challenges, such as wear of grinding parts and mill internals, are recognised and are addressed with R&D in combination with maintenance concepts.

The VRM is a mature technology in many applications, but needs adaption in some areas for the mining industry. Based on the detailed experience in non-mining industries, the challenges are well known and can be addressed. The VRM is not a one-fits-all solution,
therefore for each project the overall benefit must be evaluated regarding CAPEX, OPEX (including not only the grinding plant), and also downstream processes – because no single technology will solve the challenges alone. GMR

References

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