

LOESCHE VERTICAL ROLLER MILLS FOR MINERAL PROCESSING

Heinz U. Schaefer, Ph.D.

LOESCHE GmbH, Duesseldorf, Germany

LOESCHE GmbH, Hansaallee 243, D-40549 Duesseldorf, Germany

Phone: +49-211-535-3402, Fax: +49-211-535-35402, e-mail: schaefer@loesche.de

www.loesche.com

ABSTRACT

Grinding of ores and minerals is carried out in most applications in tube mills using wet or dry process. Although not very energy efficient this technology has proven its high reliability with a high availability and operational safety for more than 100 years.

In some industries the grinding philosophy has changed in the last decades as vertical mills became more favorable and high pressure interparticle comminution has been introduced into the markets. Recent studies have shown that the processing of ores and minerals downstream of the grinding plant might be improved by the application of interparticle comminution and by the application of a dry grinding process.

Studies for applications of LOESCHE mills for the dry comminution of ores and minerals have proven that in particular cases the recovery and the grade of the product can be improved compared to a conventional wet grinding processes in tube mills.

INTRODUCTION

Since more than 100 years tube mills of all kinds are the most common grinding tools in mineral processing. However some industries, e.g. the cement industry, have changed to dry grinding with vertical rollers mills for decades due to the low energy consumption and the high drying capability of these mills.

In the late 1980s high pressure interparticle comminution by means of high pressure grinding rolls was introduced [Schönert, 1979]. This technology was widely accepted in the cement industry for grinding of clinker and slag but also for some applications in mineral processing [Kellerwessel, 1993]. The experience with this kind of application raised in general the interest for dry grinding.

Vertical roller mills follow the interparticle comminution principle. They are known for almost 100 years. However mills for high throughput rates have been developed just in the last 3 decades

following the demands of the cement industry, which was installing steadily raising plant capacities [Brundiek, 2000]. Vertical roller mills are operating with lower pressure for comminution than high pressure grinding rolls do. Abrasive properties of the materials to be ground play a minor role therefore and can be considered by the application of wear resistant castings. Moreover the mechanical stability of the grinding tools is higher.

LOESCHE VERTICAL ROLLER MILLS

With more than 90 years of experience LOESCHE is a well reputed supplier of vertical roller mills. Manufacturers in the United States and in Japan have been licensees for many years. In the beginning of the history of LOESCHE the mills were mainly used for pulverization of coal for power plants. Nowadays the LOESCHE mill is famous for grinding of raw materials for the cement industry, but also for grinding of clinker and blast furnace slag [Schaefer, 2001] as well as for coal grinding for power plants, cement kilns and blast furnaces.

The largest mill of this kind is presently the LM 63.4, which has a capacity for 840 t/h of cement raw material at 15 % residue on 90 μm aperture size and which has an installed power of up to 6000 kW.

Smaller mills can be already found in mineral processing as well for grinding of phosphate, limestone, gypsum and other industrial minerals.

Design of the LOESCHE mill

The range of fineness of the feed for flotation or related processes is very well covered by the LOESCHE mill. Residues of 1 – 5 % on 200 μm aperture size are quite common in cement raw material grinding. Anthracite or petcoke require much smaller residues of < 5 % on 90 μm aperture size and are very well achieved as well. In cement production or in production of ground granulated blastfurnace slag a fineness of 10 % on 45 μm aperture size and less is common.

In the LOESCHE mill a flat grinding table and conical rollers are used. Interparticle comminution takes place in a material filled gap between the rotating grinding table and the rollers (Figure 1). The mill feed is charged to the center of the table and moves affected by centrifugal forces and friction towards the table's edge. On that way it is nipped by 2, 3, 4 or 6 conical rollers installed at the outside rim of the table. The rollers are attached to hydraulic cylinders which provide the grinding forces for comminution of the material.

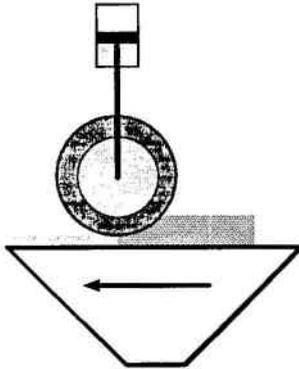


Fig. 1 : Comminution principle in the LOESCHE mills

The inclination of the conical roller creates shear forces which support the comminution and allows transportation of the material under the rollers. However the inclination is designed in a way that these shear forces are minimized in order to prevent extensive wear on the grinding rollers.

The lining of the grinding table as well as the rollers are made of wear resistant high Cr castings.

After comminution the particles leave the table and are taken up by an airstream to the dynamic high efficiency classifier which is incorporated in the casing of the mill (Figure 2). Particles of product size are leaving the mill with the air while the rejected particles are fed back to the table for further comminution together with the fresh feed.

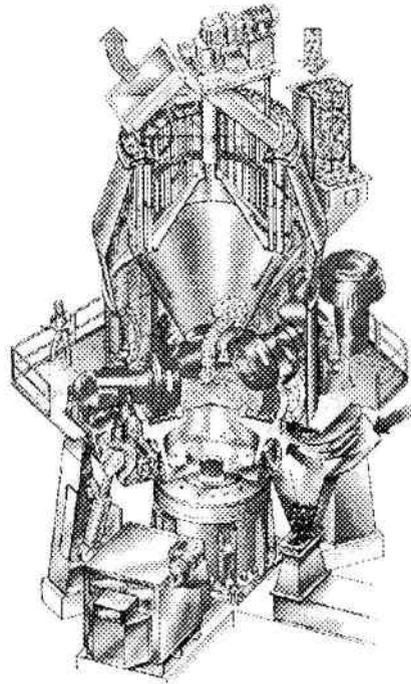


Fig 2 : Sectional view of a LOESCHE mill

The pressure required for comminution is provided by the so-called hydro-pneumatic spring system. Figure no. 3 shows the principle of the hydraulic system. The grinding pressure on the high pressure side of the hydraulic cylinder in the range between 50 bar and 100 bar is inducing the grinding forces into the material in the gap between the rollers and the table. The low pressure side of the hydraulic cylinder has a pressure of about 10 % of the pressure on the high pressure side. This allows a certain kind of elastic movement of the roller. By setting of the pressure on both sides the movement can be stiffer or softer and by this adjusted to the comminution properties of the material. Besides both circuits are connected to accumulators in the near vicinity of the hydraulic cylinder which smoothen the movement of the rollers even more. The result of this set up is a grinding performance on a very low vibration level.

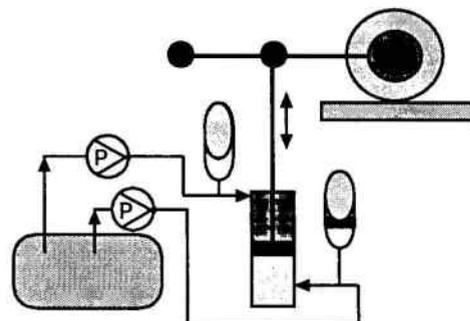


Fig. 3 : The hydro-pneumatic spring system

Mills with four rollers have two individual hydraulic systems for one pair of rollers each. Different pressure settings can be applied for each pair which is very helpful for material with poor nipping characteristics.

The hydro-pneumatic spring system is a very versatile feature on the LOESCHE mill because it allows easy adjustment of the grinding process responding to changing comminution properties of the mill feed e.g. due to the heterogeneity of the ore body itself or due to fluctuation in the moisture content etc..

Grinding plant design

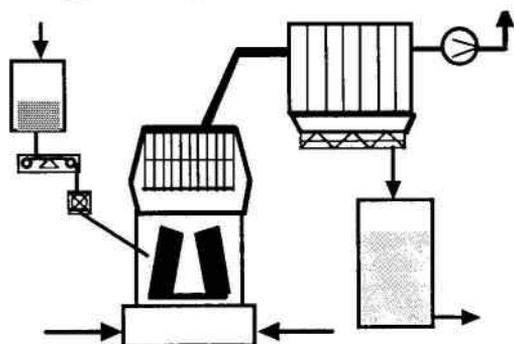


Fig. 4 : Grinding System

Figure 4 shows the flow sheet of a grinding plant. The raw feed is fed through an airlock into the mill. The required airflow enters the mill in the lower part of the housing. This air passes through the nozzle ring adjacent to the edge of the grinding table and carries the material upwards to the classifier. Draft through the mill is induced by the system fan. The finish ground material leaves the mill after passing through the rotating cage of a high efficiency separator, which is incorporated in the mill housing. The product is collected downstream of the mill in a filter and is conveyed to storage silos for later transport to the downstream stages of processing.

Depending on the application the filter might be replaced by cyclones (fig. no. 5).

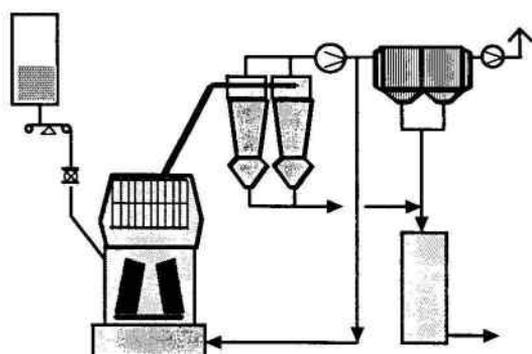


Fig. 5 : Grinding system with cyclones and air recirculation

In the above shown flow sheet in Figure 4 the air circuit is open. A closed air circuit can be installed which enables a temperature control at the mill outlet if required as shown in Figure 5. Drying in the mill can be done as well. In such a case a hot gas source might be incorporated into the circuit providing heat for drying purposes.

APPLICATION OF LOESCHE MILLS FOR MINERAL PROCESSING

Pilot plant testing

ANGLO AMERICAN RESEARCH LABORATORIES has installed a pilot plant with an LM 3.6 as well in their R & D Center in Johannesburg, South Africa (fig. no. 6). This pilot plant allows various configurations regarding the mass flow around the mill. It is installed in close vicinity to a large variety of pilot flotation units and can be operated in line with the flotation plant.

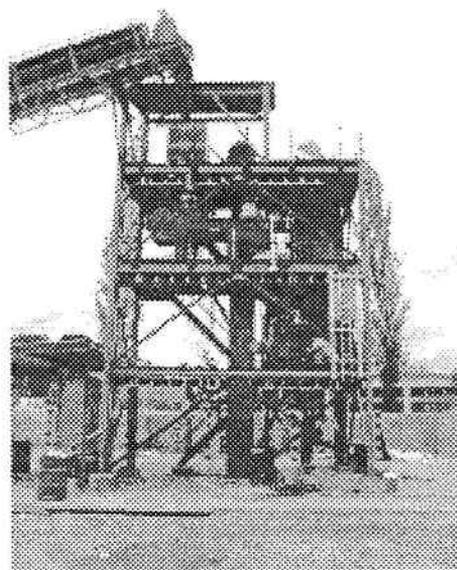


Figure 6 : Pilot plant of AARL in Johannesburg, South Africa (Photo by courtesy of AARL)

In this plant many different kinds of ores are processed. The results published by Smit et al. (2000a, 2000b) have shown that there is a potential for improved recovery and product grade when a dry grinding process with a vertical roller mill is installed. In some cases it was even possible to use a coarser product in flotation achieving the same grade like from finer feed from conventional mill systems. However the results have shown moreover that each kind ore needs to be tested individually in line with the downstream processing unit like flotation banks in order to study the influence of the mill settings on the liberation of the minerals as well as the influence of consumption and type of reagents and other parameters.

Coarse grinding of pyroxenite ore

The South African company FOSKOR carried out an extensive study on the feasibility of various dry grinding technologies for their extension of the Phalaborwa operations where an apatite carrying pyroxenite ore from the Phalaborwa igneous complex is processed. In this study the performance of a LOESCHE mill was investigated as well [van der Linde et al., 1998a, 1998b]. The first grinding tests have been carried out in the Research and Development Center of LOESCHE. Later on a pilot plant with a LM 3.6 with a capacity of approx. 2 t/h and a downstream flotation unit with a capacity of approx. 500 kg/h was installed at site in Phalaborwa. The results showed that the recovery as well as the grade of the product ground in the LOESCHE mill was superior compared to the existing rod mills using the wet process.

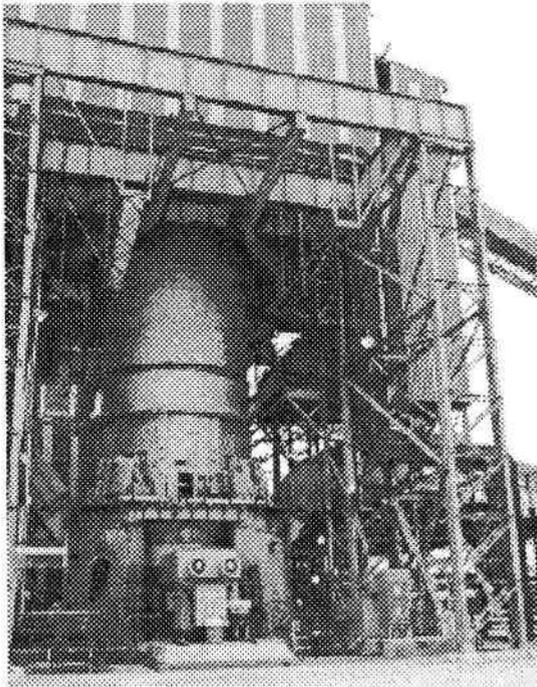


Figure 7 : LM 50.4 in Phalaborwa

Based on the result of the feasibility study a LM 50.4 was installed in the new production line at Phalaborwa for dry grinding of 825 t/h at 20 % residue on 480 μm aperture size (Figure 7). Figure 8 shows the flow sheet of the grinding plant. In the beginning of the project it was intended to take out the coarse grits rejected by the classifier and to use those grits in an other process. The classifier is installed in an elevated position for this reason and a two way chute at the bottom of the grit cone allows the grits either to go back immediately to the grinding table or to extract them from the mill and the grinding process. Due to changes during the development of the project the possibility to extract grits was no more taken into account. This mill is in operation since summer 2000.

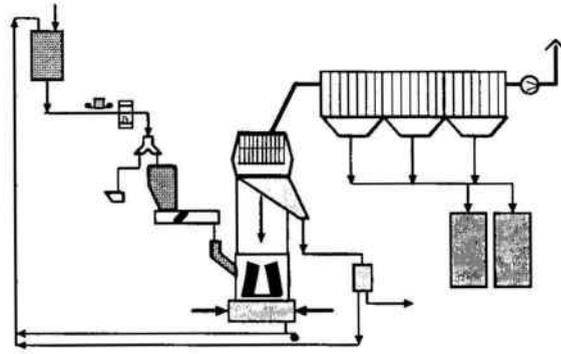


Figure 8 : Flow sheet of the Phalaborwa plant

CONCLUSION

The LOESCHE mill can cope with a wide range of fluctuations in the properties of the mill feed as mentioned above due to its hydro-pneumatic spring system.

The vertical roller mill offers a number of advantages compared to conventional grinding plants. In general the feed size is significantly larger (80 – 120 mm) compared to ball mills. A 3rd crushing stage might be eliminated therefore.

Dry grinding in general is an advantage in those places where the availability of water is limited. Besides the freshly liberated surfaces of the ore are not affected by fluent surrounding them.

The dry grinding plant can be operated independently from up- and downstream processes. This allows to optimize the performance of the plant without interfering in other operations. The ground product is stored in silos which might act as a buffer in case that the raw material processing line is shut down. The control of the density of the pulp in a flotation plant becomes easier.

The first experiences with the application of LOESCHE mills for dry grinding of ores have proven that there is a large potential for this technology due to improved product quality and easier operation of the grinding plant as well as of the downstream process.

LOESCHE will develop their system jointly with mining and mineral processing companies in this sector.

REFERENCES

- Brundiek, H., The world's largest vertical roller mills for producing cement raw meal at the start of

the 21st century. Cement-Lime-Gypsum 4, 2000

Kellerwessel, H., Hochdruck-Gutbett-Zerkleinerung von mineralischen Rohstoffen. Aufbereitungs-Technik 34, 1993

van der Linde, G.J., Advantages in dry milling – the FOSKOR experience. International Metallurgy Conference, Denver 1998

van der Linde, G.J. and Bester, P., Improved apatite recovery from pyroxenite ore using dry milling. Mining and Metallurgy Conference, Capetown 1998

Schaefer, H.-U., LOESCHE mills for grinding of clinker and slag and for the production of cements with interground additives. Cement-Lime-Gypsum 1, 2001

Schoenert, K., "Verfahren zur Fein- und Feinstzerkleinerung von Materialien spröden Stoffverhaltens". German Patent 2 708 053

Smit, J.T., Du Plessis, I., Viljoen, R.M., Mineral liberation by pressure comminution optimized for downstream processing. 2nd Annual Crushing and Grinding in Mining Conference. Johannes-burg, Feb. 14 + 15, 2000

Smit, J.T. and Viljoen, R.M., Mineral liberation by pressure comminution. Proceedings of symposium "Experience by Dialogue" of LOESCHE GmbH, Duesseldorf 2000