OPTIMIZED FINE GRINDING OF CERAMIC SLIP WITH THE AGITATED MEDIA MILL MAXXMILL®

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ABSTRACT

The analyses of grinding processes with ceramic slip in the MaxxMill®, a vertical open agitated media mill, have revealed a distinct potential for optimization, which has already been picked up in the industrial practice. The use of grinding bars instead of grinding disks substantially improves the conversion of energy, and consequently allows clearly higher throughput rates to be achieved. The bar agitator with a circumferential speed of up to 6.5 m/s is therefore preferable in terms of an energy-optimized preparation process. Up to these speeds, wear on grinding tool and balls is also still kept in cost-effective limits.

As was examined for different machine sizes the scale up can be made on the measured specific energy consumptions for different end finenesses.

1. MACHINE TECHNOLOGY

The MaxxMill® was developed for the dry and wet grinding of coarse-grained raw materials down to fine and ultra-fine end products. The construction principle consists of one or several eccentrically positioned agitators, a vertical, rotating grinding chamber, and an eccentrically positioned stationary flow deflector. The diagram in figure 1 shows the configuration of the MaxxMill® with one disk and bar type agitator as well as a photo of an opened MM5 with 2 eccentrically positioned bar agitators.

Figure 1. Configuration of the MaxxMill® - disk type tool (left), bar type tool (middle), opened MaxxMill® MM5 with 2 eccentrically positioned bar agitators (right)

The grinding chamber is open at the top and up to 80 to 90% of its volume is filled with grinding balls. Through the hollow flow deflector, the material to be ground is introduced vertically into the mill from the top down close to the bottom. The material continuously passes through the moving grinding ball package from the bottom to the top, and is effectively comminuted by means of the energy input at the agitator(s), the variable compression of the grinding ball batch in the area of agitator(s) and flow deflector, and the compressive stress close to the bottom. In a wet grinding process the grinding balls are separated from the product in the upper section of the grinding ball batch by means of screening cartridge. Feeding and discharging of material is performed continuously via controllable peristaltic pumps.

2. TEST SET-UP

Detailed test series for the influence of the operating parameters on the grinding results on a 6 liter lab scale size R02Maxx and a 200 liter production size MM3 are described in [1].

The test results discussed below were obtained on a production-size agitated media mill MaxxMill® MM3 with a grinding chamber volume of 200 liters and one eccentrically positioned agitator, and on a MaxxMill® MM5 production mill with a grinding chamber volume of 800 liters and two eccentrically positioned agitators featuring a similar geometry. For the tests a porcellanato body was used, with an inlet sieve residue of 3% > 45 μm, at a suspension density of 1700 g/l. Unless specified differently, the MM3 was filled with 300 kg and the MM5 mill with 1370 kg of grinding balls, made of 92% aluminum oxide, diameter 4 to 5 mm.

3. INFLUENCE OF GRINDING TOOL GEOMETRY AND ROTOR SPEED

From the different grinding tool geometries, developed by different manufacturers in the history of the closed agitated media mill, it is known that the shape of the grinding elements affects the distribution of energy density inside the grinding chamber. Normally, vertical agitated media mills are equipped with bar agitators for dry grinding tasks and disk agitators for wet grinding tasks; the influence of the agitator geometry (disks, bar agitator – figure 1) on the energy input and grinding result will be analyzed below

Figure 2 shows the influence of the throughput rate on the final fineness. As already published in [1] higher capacities can be achieved with a bar type rotor tool in comparison to a disc type tool with the same final fineness on lab scale size (6 liter) as well as production size (200 liter). Indeed, in these trials the difference in throughput rate on MM3 with disc type tool is relatively small with a circumference speed of 5.2 m/s and is only a few percent points.

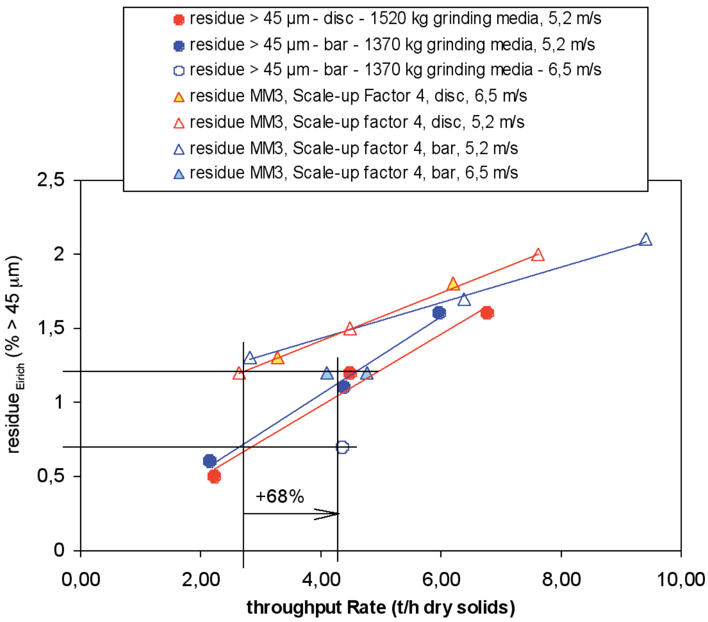

Figure 2. Influence of the throughput rate on the sieve residue by different rotor tools and tool speeds

If one compares the at most attainable results achieved with the disc type tool with 5.2 m/s, which are almost identical with the results achieved with a bar type rotor tool with a speed of 6.5 m/s, it appears that with a residue of 1.3% > 45 μm an increase of the throughput rate of approx. 68% is possible by use of the bar type tool. This corresponds with the investigations on other ceramic slips made on the MM3 [1].

The same applies accordingly to the investigations on the MM5 with a residue of 0.7% > 45 μm. Also in this case the throughput rate can be increased by approx. 68% with the same final fineness when the disk type tool is replaced by a bar type tool and the rotor speed is increased from 5.2 m/s to 6.5 m/s. With the experiments made on MM5 it appears that throughput rates achieved at the same fineness with a bar type tool and a circumference speed of 5.2 m/s are slightly smaller than with the disk type tool. This can be attributed to the different grinding media load of 1520 kg for the test with disk type tool.

The comparison of the throughput rate of MM3 and MM5, while the throughput rate of the MM3 is already scaled-up by the assumed volume based factor 4, is shown in figure 2. Because the final fineness measured on the MM5 is always below the one measured on MM3 with the same throughput, the efficiency of the MM5 is rather higher than the assumed 4:1. If one reconciles the curves measured from MM3 and MM5 the calculated scale-up factor will be at about 4,5, which corresponds to the grinding media load ratio between MM3 and MM5 (1370 kg/300 kg = 4,56).

BIBLIOGRAPHY

[1] Klein, G.; Schulze, G.; Gerl, S.; Sachweh, J; Optimization of the MaxxMill for Wet Grinding of Ceramic Slips; Interceram, (2005), Vol. 54, No. 5, S. 320 - 327