Superfine Grinding of CPC with Ball Race Mills – Challenges and Solutions

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Abstract

Claudius Peters did supply several Ball Race Mills to Aluminium Smelters worldwide. The standard application is fed by a calcined petroleum coke with a size <10mm and produces a fine material with a specific surface of 4000 Blaine. In order to develop the system, further tests have been made to identify parameter for a finer finished product. The challenge was to provide CPC dust with 6000 Blaine with similar equipment as the 4000 Blaine material. Such high fineness can be managed following basic rules of grinding in air swept mills. Tests have been done on an industrial scale to verify the effect of such a change of the parameter. The specific power consumption rises from 100 % to 200 % and the iron contamination rises accordingly. Due to the fineness the mill power decreases from 100 % to 67 %. At the end, the mill capacity decreases significantly, but all challenges found a safe and sound solution. The different target could be met without modification to the equipment.

Keywords: Grinding, material handling, energy efficiency, fine grinding.

1. Introduction

Claudius Peters did supply meanwhile 17 EM Ball Race Mills to Aluminium Smelters worldwide. For standard applications mills are available as shown in Figure 1.

The mill shown in Figure 1 is a modern vertical ball ring mill with a dynamic classifier. The material to be ground is fed to the ball ring mill centrally from the top where the material falls down onto the rotating grinding yoke. The yoke and the lower grinding ring are driven by the mill gear. The upper fixed grinding ring, pressed down by the hydraulic system, holds down the grinding balls.

The calcined petcoke is now crushed between the grinding elements and grinding rings and then transported out of the grinding track by centrifugal forces. An air flow directed upwards captures the now ground petcoke and directs it to the classifier integrated in the mill. The excessively large particles are separated from the other particles inside the classifier and return back to the grinding mechanism for renewed grinding. The other particles leave the mill together with the transport gas. The use of a dynamic classifier makes it possible to produce the highest fineness and steepest particle size distribution lines.

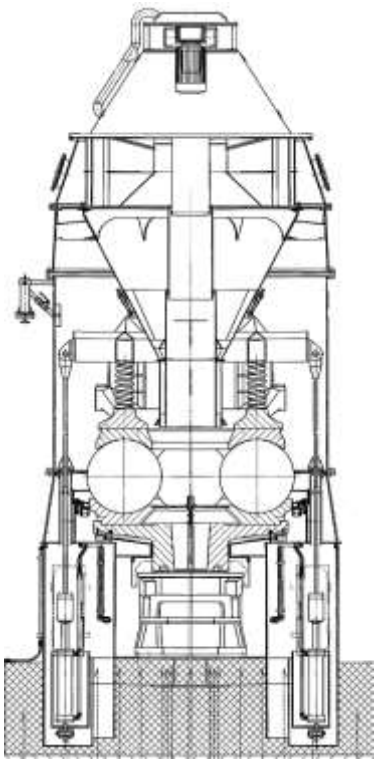

Figure 1. Claudius Peters EM-Mill

The introduction of the vertical spindle mill for production of the fines for the anodes has improved the consistency and quality of the anodes remarkably.

The advantages of this new grinding principle in comparison to the traditional horizontal tube mill amongst other are [2,3,4]:

Product Quality of Fines

The product quality of the fines - defined among other things by the median d50 and the range of particle size distribution, the specific surface according to Blaine and the metallic matter from the wear of the grinding elements which come into contact with the product - has a main influence on the production of the green anode paste.

For the production of a consistent anode the consistency of the grain size distribution and the specific surface are decisive.

Metallic components determine the quality of the anode, this way having a negative influence on the quality of the aluminium since they enter the molten metal when the electrodes are burnt during the electrolysis.

Fines Grain Size Distribution

The properties of the fines, characterized by the average grain diameter d50 and the grain size distribution or Blaine number, influence the production process of the green anode paste and thus the quality of the anodes.

Continuous Operation of the Vertical Spindle Mill

Conventional grinding processes using a horizontal tube mill with very limited turn-down ratio must be operated in start / stop modus in order to meet the production requirements. With the vertical spindle mill, however, the actual capacity can be turned down by between 100 and 25

However, we have to remember that the power consumption at super fine grinding is lower as in standard applications. We can correct the expected mill capacities using the power factor $f_{P\%}$ of Equation (1).

$$\dot{m}_{rel,corr} = f_{p\%} \cdot \dot{m}_{rel,expect} \quad (7)$$

with
$f_{p,\%}$ Power factor, %
Example:
With:
S_M = 6200 cm²/g
$\dot{m}_{rel,\ expected}$ = 50%

$$f_{p\%} = (0{,}000000016 \cdot 6200^2 - 0{,}00028 \cdot 6200 + 1{,}8)\% = 68\% \quad (8)$$

$$\dot{m}_{rel,corr} = f_{p\%} \cdot \dot{m}_{rel,expected} = 68\% \cdot 50\% = 34\% \quad (9)$$

5. Conclusion

We see, that the curve called "corrected capacity" fits very well to the curve called "achieved capacity" in Figure 12 and we can estimate quite exact the mill capacity for a fineness in the range between 3500 and 7000 cm²/g (see Equation 2) with this method.

This proves the well-known rule that vertical mills prefer coarse feed. With reasonable coarser feed the mill power consumption and the maximum mill capacity are is higher. This is opposite to horizontal mills, usually called ball mills, which prefer fine feed. Therefore, it is in general not good to exchange in plants a horizontal mill against a vertical mill without changing the fineness of the pre-grinder.

6. Outlook

Grinding tests for a material quality with a very high fineness have been carried out in the industrial scale grinding plant. The same equipment as for coarse grinding has been used. Only the operating parameter have been changed. The tests did prove that only with small adjustment changes, completely different qualities can be achieved.
If a high rate of fines is requested, the ball race mill is a vertical mill which suffers from fine feed only in a moderate way, the mill capacity is reduced. And this moderate suffering can be estimated quite exact after the a.m. tests.
During service life of the grinding elements the grinding balls will keep its shape and the capacity of a ball race mill will not decrease, which is very different compared to other vertical mills.

7. References

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