Five reasons for measuring density in grinding circuits

DENSITY IN THE GRINDING CIRCUIT
WHITEPAPER
INTRODUCTION
Are you struggling with your ball mill or cyclone operation? In grinding circuits, operators are managing different pieces of equipment. This whitepaper describes the purposes and benefits of measuring density at different applications in the grinding circuit. First, a short introduction to the grinding process and control purposes are given, followed by five key reasons for measuring density.

THE GRINDING CIRCUIT
In general, the grinding circuit is composed by a powdering or pulverizing process and a classification process. In most sites a ball mill is used for grinding, to produce fine particles, and a (hydro) cyclone is used for classification, to separate the fine particles from larger particles. The finer particles are forwarded to next process stages, while coarse particles are returned to the ball mill for regrinding.

PURPOSE OF PROCESS CONTROL
The main objectives when controlling the grinding circuit are to maximize the throughput, and to decrease variability of product size and % solids, to remove material that meets the product size requirements from the circuit and recycle coarse material back to the grinding mill for further comminution.

To achieve these objectives the slurry needs to be continuously monitored and controlled, allowing process stabilization and ensuring optimal grinding conditions.

MEASURING POINTS
In the grinding circuit possible installation points for density meters are in the ball mill discharge and feed (recirculation), (hydro) cyclone feed, overflow and underflow.

Figure 1: Measuring points in the grinding circuit
WHY DENSITY MEASUREMENT?

Instruments, such as density meters efficiently help operators to monitor and control the grinding circuit, optimize it and prevent process failures.

When used together with an advanced control system, density readings allow to automatically control valves, pumps and have an efficient water addition, resulting in the improvement of the process that can lead to a higher recovery.

There are multiple reasons for measuring density in the grinding circuit, which could differ per application. The following five topics are highlighting the main reasons for measuring density in the grinding circuit.

1: VERIFY STEADY OPERATION

Operators want to know if the ball mill is grinding fine enough. To verify changes, density samples are usually taken, as density has a high correlation with particle size. Density variation indicates changes in the circuit. Therefore, the density value is used to check if the grinding process is operating steadily or not.

Taking samples manually is an old practice. The search for automation and process improvements (industry 4.0) is leading to the use of in-line measuring devices capable of detecting changes in real-time. As an example, a recommended application to efficiently dose grinding media (balls) and water into the ball mill is measuring density changes in the ball mill discharge.

2: OPTIMAL CLASSIFICATION

The cyclone utilizes centrifugal force to accelerate the settling rate of slurry particles and separate them according to size, shape, and specific gravity.

Due to centrifugal forces, faster settling particles (coarse) move to the wall of the cyclone, where the velocity is lowest, and migrate to the underflow. Slower-settling particles (fines) move toward the zone of low pressure along the axis and are carried upward to the overflow.

A certain slurry density is needed for optimal (re)classification of particles in the cyclone. The cyclone has proved extremely efficient at fine separation sizes. However, for middle size particles this process is less efficient.

When too much water is added to the process, more middle size particles are produced by the ball mill, so the cyclone overflow allows a lot of these middle size particles to escape the grinding circuit. This results in a decrease of material that the ball mill would have to grind, which lowers its efficiency. Also, unwanted particle sizes are leaving the grinding circuit to next process stages.
For optimal classification of particles, it is important to detect changes in real-time in the cyclone feed. An optimal control of the cyclone can be achieved by controlling the % solids in the feed flow to a desired target, which is done through the use of a density meter. The cyclone overflow and underflow can also be monitored by density meters. Other crucial parameters to be monitored are the pressure and particle size.

**3: POOR GRINDING**

Too much solids content (overloading the grinding circuit) can result in poor grinding. Therefore, the slurry density should be kept within the targets and parameters defined by the process personnel. Water can be used to dilute the slurry and control the density in the process. Adding water could help to reduce the amount of middle sized particles in the grinding circuit. In this way, poor grinding caused by an overload of solids could be prevented. Continuous (real-time) measurement is needed in the grinding circuit to check if the density is kept within the optimal conditions.

**4: HIGH CIRCULATING LOAD**

If the cyclone keeps returning ore to the ball mill, the total volume of ore will be increasing in the grinding circuit, as is the density of the slurry. The recirculating ore is also called circulating load. If the grinding process becomes less efficient, the circuit load will climb until its volume is greater than can be handled.

The density meter can be applied in the grinding circuit as a warning system. Thanks to real-time density measurement, an increase of circulating load can be detected on-time, to be able to control the process before problems become unmanageable.

**5: UNAVAILABILITY OF PSA**

The particle size is an important indicator of the performances of the grinding circuit. Therefore, this is normally measured by online particle size analysers. When the value from the particle size analyser (PSA) is not available, it affects the control loop. In an automation project at a grinding circuit in South Africa, a self-correcting particle size predictor has been developed to overcome this problem. This was described by Mr. B.J. du Plessis in a paper which was published in the *Journal of The South African Institute of Mining and Metallurgy*.

The predicted value was based on the slurry feed density, volumetric flow rate and pressure drop over the cyclone. Using these variables in a model, they were able to calculate the predicted value, which was done every five minutes.

At a certain moment the PSA’s value was lost, when it came back, the predicted value was still in close agreement with the actual...
value. This eliminated problems associated with periods of unavailability of the particle size analyser. The calculation model was based on work which was done by other researchers, Weiss (SME Mineral Processing Handbook) & Wills (Mineral Processing Technology Handbook).

AVAILABLE EQUIPMENT

Density measurement is usually done by radiation-based measuring devices. This technology has been used in the mineral processing industry for decades. However, nowadays governmental regulations are getting stricter and associated costs are increasing. More nuclear density meters are being replaced by alternatives. These alternatives can do the same job, without administration costs and health and safety risks related to the nuclear source.

Besides density, flow and particle size measurements are also important for monitoring the operational performances of the grinding circuit.

SLURRY DENSITY METER (SDM)

The eco-friendly Rhosonics Slurry Density Meter (SDM) has been introduced in 2016 and is the first real alternative to substitute nuclear density meters, reaching hundreds installations worldwide in just a few years.

CONCLUSION

As discussed in this article, measuring density in the grinding circuit is important, for monitoring and improving process efficiency and preventing high density increases and problems with the circulating load. Density is used as a performance metric for ball mill and cyclone control.

MORE INFORMATION?

Rhosonics has more than ten years of experience in using ultrasonic technology for non-nuclear density measurement in the mineral processing industry. We can help you to replace nuclear density gauges in different applications. Our density meters are used in different applications, such as ball mills, cyclones, flotation cells and in the thickening process.

Please contact Rhosonics if you want to learn more about density measurement in a non-nuclear way. Our team is ready to replace your nuclear density gauge.
MEASURING BEYOND LIMITS

Rhosonics is based in the Netherlands in Putten. We design, produce and supply state-of-the-art measuring instruments for virtually any industry. The company cooperates with partners worldwide to offer the best technology solutions. We use craftsmanship, capability and creativity to create measurements beyond limits.

We proudly meet the requirements for the ISO9001 standard since 2010.

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