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Figure 1: The drum interior at Garpenberg during a service stop clearly shows the rubber lifters. The rubber lifters are clearly visible.



Figure 2: The autogenous mill at the Boliden Garpenberg Mine

The Perfect Pair

Shock Pulse and Vibration Monitoring Combo Pays Off at Boliden Mine

by Tim Sundström

IN THE MINING INDUSTRY – one of the most capital-intensive industries in the world – preventive maintenance makes good business sense. In a process involving high costs and specialized equipment, the grinding mill is not only the most energy-consuming processing unit, it is also a highly critical application. It stands to reason that optimizing this bottleneck is of pivotal interest to the industry. Swedish mining company Boliden successfully combines a shock pulse measurement technique and vibration analysis to do just that.

This technology has become a game changer when it comes to reliable condition measurement on low speed and other hard-to-monitor applications. Having performed extensive testing and evaluation of this installation on the autogenous mill in its Garpenberg mine in central Sweden, Boliden is an early adopter of this technique in the mining industry.

If the grinding mill malfunctions, the entire production process at Garpenberg can be severely limited or completely halted. Therefore, close observation of mill equipment condition is essential. A potential breakdown of this plant stopper directly affects total mine output and cost per ton. The consequences may range from extensive process limitations to a complete production stop with significant financial implications.

But monitoring the condition of a grinding mill is not a trivial task. Variable process characteristics and a noisy environment creating interference with desired signals all contribute to making successful condition monitoring difficult. To further complicate things, grinding mills run at fairly low, and in some cases variable, revolutions per minute (RPMs). Under these conditions, traditional vibration measurement techniques alone do not yield clear answers. When combined with shock pulse measurement, on the other hand, these

problems can be overcome in a solid technical solution.

Grinding Mills

Part of the concentration plant, the grinding or tumbling mill is a large-scale grinding device (see Figure 2) used in mineral processing to grind large chunks of ore into a suitable size for the next step in the concentration process. A similar setup is used in the cement industry for crushing clinker.

There are several different types of grinding mills: ball, rod, autogenous and semi-autogenous grinding (SAG). In a ball mill, steel or stone balls are mixed with the ore and during rotation of the drum, the ore is ground by friction and compression into a suitable fineness. A rod mill uses a similar principle, but the steel or stone balls are replaced by rods to create the grinding action. In an autogenous mill, the ore itself is used in the grinding process. A SAG mill is a combination of a ball mill and an autogenous mill.

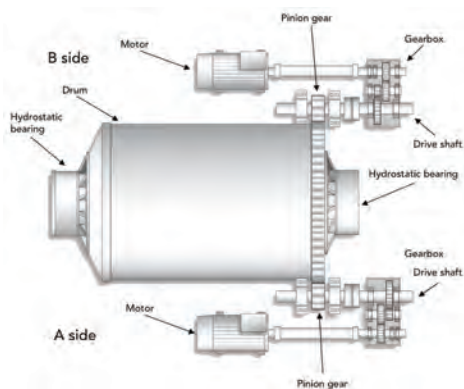


Figure 3: The autogenous mill seen from above

The main component of all mills is a horizontal rotating drum, typically with a rubber liner and regularly spaced lifter bars (see Figure 1). Generally, the ore is continuously fed into the drum in one end, then crushed and transported out in the other.

In autogenous mills, a sufficient amount of bigger parts of ore inside the drum is critical to an effective grinding process. Maintaining particle size while minimizing equipment wear, downtime and power consumption is a challenge to production and maintenance engineers.

The Garpenberg Autogenous Mill Case

The online system Intellinova Compact with SPM HD with shock pulse measurement technique was installed for trial measurements on the autogenous mill in Garpenberg in January 2012. Between then and October 2013, two serious problems were detected well before any serious consequences: a bearing damage in one of the two gearboxes and a loose (wobbling) gear in the same gearbox. Had they gone undetected, both problems might have caused serious malfunctions with severe economic consequences.

The combination of vibration and shock pulse measurement is ideal for this type of application. The shock pulse technology is very suitable for detection of bearing damages in noisy environments, such as in these gearboxes, while vibration technology is optimal for low frequency related fault conditions, like unbalance, loose gears and misalignment.

The Technical Solution

The main part of the autogenous mill is the drum, rotating at approximately 15 RPM and driven by two frequency controlled motors on opposite sides of the drum. Via a two-stage gearbox, a pinion gear drives the drum itself.

A total of 28 installed transducers cover the motors, gearboxes and drive shafts, with 10 shock pulse transducers and four vibration transducers on either side. In addition, two RPM probes are mounted on the drive shafts.

The shock pulse transducers are mounted as closely as possible to the load zone to pick up bearing related signals. Since they do not detect low frequency signals, the purpose of the vibration transducers is to cover such low frequency movements.

Using shock pulse transducers with SPM HD for bearing condition assessment in gearboxes yields superior capability to detect bearing condition. The multiple gear mesh frequencies in a gearbox significantly affect normal vibration transducers, making the spectrum and overall values very hard to interpret. The shock pulse transducer, however, is not affected by the gear mesh (if there are no gear damages), hence the readings are very clear and crisp, showing bearing condition only. This is because normal mesh frequencies are too low to be detected by the shock pulse transducer. If a crack or surface imperfection were to occur in one or several gear teeth, the shock pulse transducer would react due to the shocks.

Measurement Setup

Since the mill is running continuously, no triggers or measuring conditions are applied. The parameters followed and trended are high energy shocks (HdM) and vibration velocity RMS. A moving average filter with 10 readings applied to both parameters has proven useful in avoiding false alarms caused by random high readings.

For gear mesh trending, band values from acceleration spectrums are useful, again, with a moving average filter of 10 readings.

The measurement interval is set to one reading every two hours; however, since the damage development process is relatively slow, twice a day would be more than enough.

The standard spectrum setup for the shock pulse readings is 1600 lines, symptom enhancement factor equals 10 and an upper frequency of 100 orders.

The two vibration transducers mounted on the gearbox input shaft are used to detect all gear mesh frequencies in the gearbox. A 6400 line spectrum is used and order tracked with an upper frequency of 100 orders. Because this shaft has this application's highest speed, the 100 order upper frequency setting enables all gear mesh frequencies to be detected in the vibration spectrum. Alternatively, pseudo tach may be used.

By applying bands around the gear mesh frequencies in the spectrum, its amplitude can be trended, revealing gear problems in the gearbox.

Very Good Results

From the very first reading in January 2012, the

drive side on one of the gearbox's middle shafts showed a very unstable trend, with the occasional clear outer race signal pattern mixed with a clear inner race pattern. On bearing replacement 10 months later, clear inner and outer race spalls were found in the bearing (see Figure 4).

Twenty-four months after installation, the system in Garpenberg continues to perform very well. System sensitivity and long forewarning times enable the planning of maintenance actions well in advance, giving full control of this process critical application. The technical solution at Garpenberg can be used for all types of grinding mills.



Figure 4: The inner race of the gearbox middle shaft bearing.

Boliden Garpenberg

In operation since the early 13th century, Garpenberg is Sweden's oldest mine. After being acquired by Boliden in 1957, exploration work has resulted in a substantial increase in Garpenberg's reserves of complex ore containing zinc, copper, lead, gold and silver.

The Garpenberg mine is currently in the midst of a major expansion, where ore production will increase from 1.4 to 2.5 million metric tons of ore per year. In this process, condition monitoring plays a key role in maximizing availability and securing production. The expansion will be carried out between 2011 and 2014, with production being successively increased. Full production capacity will be reached by the end of 2015.

www.boliden.com/Operations/Mines/Garpenberg/



Tim Sundström has a Master of Science degree in Applied Physics and Electrical Engineering from Linköping University, Sweden. For over 20 years, he has been specializing in electronics development and has held managerial positions in the field since 1992. In 2001, he joined SPM Instrument as head of Research and Development, where he has been deeply involved in SPM HD development and field evaluations. Sundström is a certified Category III vibration analyst through Mobius Institute Board of Certification. www.spminstrument.com