Mills and GMDs

Maarten van de Vijfeijken* looks at large, larger and the largest units in grinding ore

The gearless motor (also called wrap-around motor or ring motor) is a very large synchronous motor. The poles of the motor are directly installed on a pole flange on the mill shell: this means the mill body becomes the rotor. The stator of the gearless motor is then wrapped around the mill. With this innovative concept the gearless mill drive (GMD) eliminates all critical mechanical components inherent within a conventional mill drive system, such as ring gear, pinion, gearbox, coupling or air clutch, motor shaft and motor bearings. Eliminating such components significantly increases the efficiency and the availability of the mill. The gearless motor is fed by a cyclo-converter which lets the operator easily vary the mill's operating speed. ABB (then BBC: Brown Boveri & Cie) installed the world's first GMD in 1969. This 6.4 MW GMD powered a 16′ cement mill in Le Havre (France), which today, some 40 years later, is still operating.

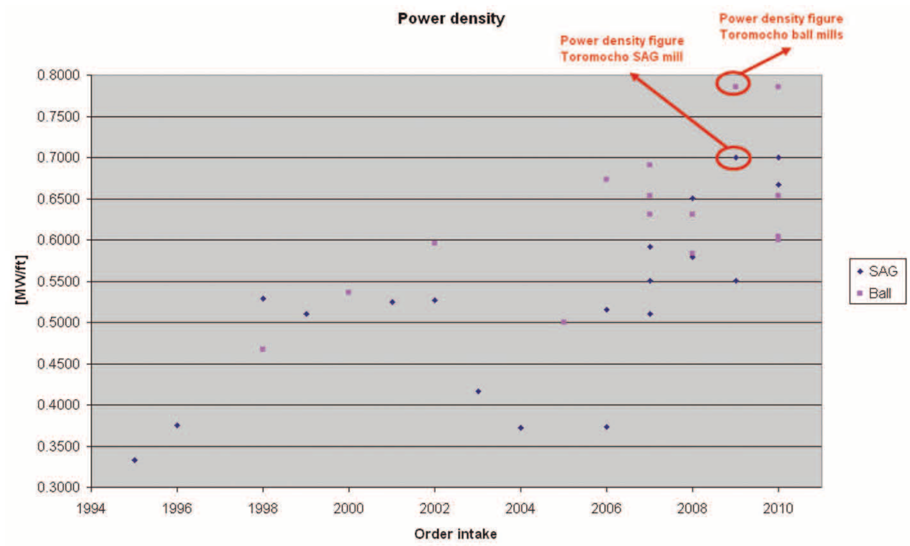
In the mid-1980s, the GMD was introduced to the minerals market as the powerful and reliable drive system for SAG mills. Early SAG mills had a diameter of about 32′, later increasing to 34, 36, 38 and 40′. At the same time the mill volume also increased. Typically a SAG mill has a much larger diameter compared to its length. Yet the SAG mill of Newmont's Yanacocha mine in Peru is a single stage mill (no ball mill after the SAG mill) and has a diameter and length of 32′, driven by a 16.5 MW GMD from ABB.

Above the Arctic Circle in Sweden, Boliden has just installed two 38′ diameter mills with an astonishing length of 45′ each, at its Aitik36 project. These, which have the world's largest volume, are solely AG mills, i.e. no ball charge. They are driven by 22.5 MW GMDs from ABB.

However, there appears to be no limit. ABB has manufactured a 28 MW GMD for a 40′ SAG mill for the Toromocho project (Minera Chinalco Perú), delivered in 2010. This is not only going to be the largest GMD, but at 4,600 masl in the Andes will be the first GMD at this altitude. And, in another project, ABB received an order to supply another 28 MW GMD for a 40′ SAG mill. Furthermore ABB won the detailed engineering of the 28 MW GMD for the world's first 42′ SAG mill for the Minas Conga oxide gold copper project in Peru. There are numerous GMD projects for 40′ SAG mills in the pipeline for the near future, as well as some other 42′ SAG mill projects. Furthermore, ABB has GMD designs ready for 44′ diameter SAG mills with a rated power of up to 35 MW.

As well as ever larger SAG mills, ball mills are also expanding in size. In the late 1990s the trend moved towards using GMDs to power these larger ball mills, as well as using the drive to vary the speed. GMDs quickly moved from 20′ ball mills, expanding to 24, 25 and then 26′ mills. In early 2010 ABB commissioned the first GMDs for two 27′ ball mills in Chile with a rated power of 18.6 MW each. However, the Toromocho project is pushing the limits further with two 22 MW GMDs being supplied to power two 28′ ball mills. A further order has just been received for another project to supply two 22 MW GMDs for 28′ ball mills.

The world's first two 40′ SAG mills are driven by GMDs rated at 20 and 21 MW respectively. But during the last three years, several GMDs for 40′ mills have created a trend for larger powers from 22 through to 28 MW. Thus, not only is the mill diameter increasing, but also the 'power density', i.e. the ratio power/mill-diameter. A similar trend can be seen with ball mills. The first 26′ ball mills had a rated power of 15.5 MW, whereas today the range is typically from 16.4 to 17.5 MW. The figure shows the power density figure for SAG and ball mills over the past 15 years, during which ABB was supplying the GMD.



Power density of ABB's Gearless Mill Drives

These higher power densities impact heavily on the detailed design such as cooling of the gearless motor, or, as in the case of Toromocho, the high altitude. Furthermore, mechanical parameters are affected. For example the rated speed of a mill is typically in the range of 74 to 78% of the critical mill speed. This is a direct function of the mill diameter, which means that the rated speed for mills of the same diameter do not vary significantly. Therefore, the higher power density values discussed above, consequently lead to higher torque density values within these GMDs.

GMDs at high altitude present an additional engineering challenge. For example, the air is thinner and the cooling efficiency is reduced. The voltage creepage distances need to be larger and this has an impact on the winding insulation system. ABB has performed high altitude testing of the full continuous VPI insulation system in a hypobaric chamber, simulating an altitude of 5,000 masl. High altitude also affects the personnel involved with installation, commissioning, operation and maintenance. As such, designing and manufacturing these very large GMDs is a real engineering challenge taking into consideration all of the above together with appropriate safety margins. ABB is the only supplier of GMDs in operation at altitudes over 4.000 masl.

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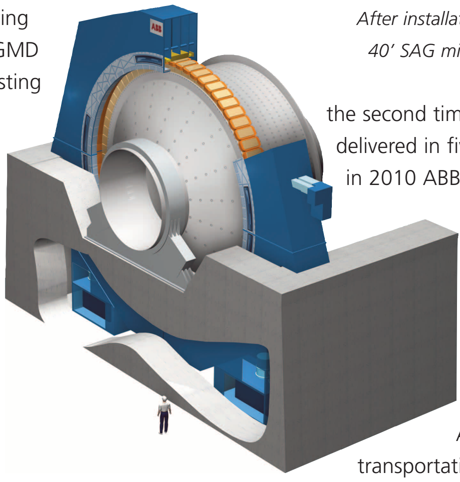
Alongside design, manufacturing and installation, transporting a GMD to site also provides some interesting challenges. GMDs consist of extremely large and heavy parts. The stator, for instance, is so large that it is typically split into four sections to ease transportation. On arrival at site these stator quarters are then wrapped around the already installed mill. For example, one stator segment of Toromocho's 28 MW SAG mill GMD has transport dimensions of SOME 14.8 x 6.1 x 3.4 m with a weight of 130 t. It soon becomes apparent why the gearless motor factories are located very close to harboUrs. For Toromocho, however, the real transportation challenges are the many bridges and tunnels throughout Peru.

Another transportation challenge is presented by the delivery of a 22 MW GMD for the 40' SAG mill of Terrane Metals' Mt. Milligan project. Located 155 km northwest of Prince George in central British Columbia, Canada, the heavy parts need to be transported in winter, when the ground is frozen. Even so, weight restrictions mean that the stator has to be split into five parts. This is the second time that a stator is delivered in five parts: earlier in 2010 ABB successfully installed and commissioned a GMD in Chile, where the stator was split accordingly. After transportation, installation and commissioning, the mill can begin grinding the ore. It is well known in the industry that a few years ago there were some failures with large GMDs, some more severe than others. With regular inspections and earlier corrective action, the impact of some of the failures could have been reduced. However, in response to past failures, ABB has implemented several design modifications, more stringent quality assurance procedures, design reviews and has developed additional protection features; resulting in a more maintenance friendly GMD system. Aiming for increased reliability, availability and trouble free lifecycle, ABB offers a comprehensive structured service and support infrastructure. Throughout the GMD's lifecycle ABB's engineers are available to help with installation and commissioning; operation and maintenance; and upgrade and retrofit. For example, detailed preventive maintenance programs are highly recommended to avoid any unnecessary downtime. Underpinning each of the lifecycle phases are service contracts, training and technical advice.



After installation, the stator of a 40' SAG mill is over 21 m high

With the Toromocho project, the combination of power density and operational altitude will deliver unsurpassed milestones in the history of grinding. Success will be achieved by diligently responding to increased demands in design, manufacture, transportation, through to installation, commissioning, operation and maintenance. The demand trend of larger diameter mills with higher power density, availability and reliability will continue to drive innovation, engineering and service creativity. The key industry drivers of this trend are the exhaustion of lower grade orebodies and the overall efficiency and availability provided by large mills driven by GMDs. So where will this end? Well, as long as the demand for larger diameter mills with higher power densities prevails, then we at ABB will continue to push the boundaries. ***IM***