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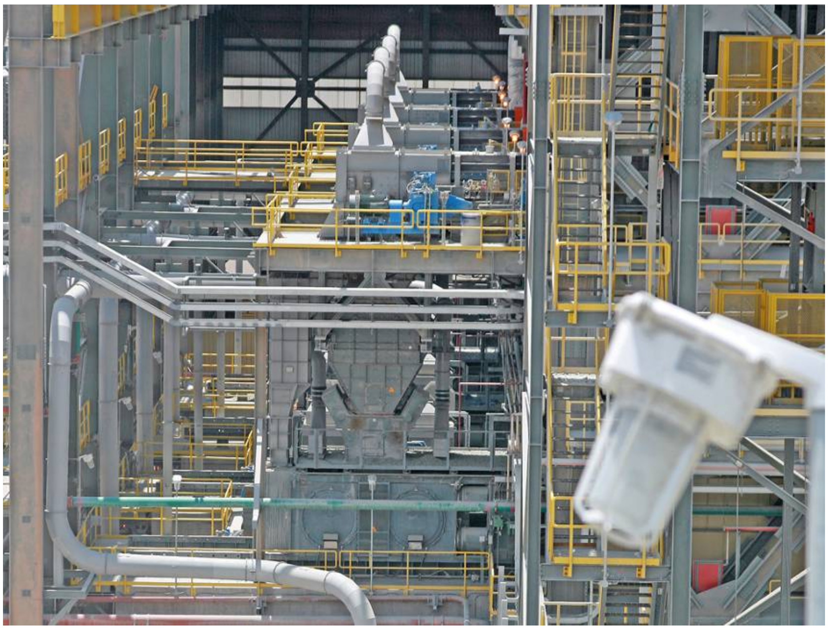
HPGR – Accepted Technology in Mining

High Pressure Grinding Rolls have been used in grinding cement clinker and associated raw materials since 1985, and had found a niche market in diamond ores and in pellet feed preparation. However their entry into hard rock mining was not secured until recently, with the successful commissioning and operation of the rolls at Cerro Verde in Peru.

Since then, the growth has been steady and persistent. HPGRs are now accepted as a viable alternative to SAG mills. This has prompted an endless number of trade-off studies comparing the two systems. With energy prices going up, and the rolls requiring less energy for grinding than SAG mills, decisions are coming down on the side of HPGRs particularly in the case of hard ores. This is not only applicable to large scale projects but also to smaller operations, as will be shown in this paper.



Cerro Verde's four HPGR Polycoms 24/17

Cerro Verde is a copper-molybdenum concentrator. The circuit consists of four (4) HPGRs, rolls 2.4 m diameter x 1.65 m wide, working in closed-circuit with eight (8) 3 x 7.3 m wet screens. Each is powered by 2 x 2500 kW variable speed drive units. They were commissioned at the end of 2006. By mid-2007 the plant reached its design capacity of 108,000 t/d, and a few months later was operating above design capacity; this continues to be the case two years on. Each unit handles between 2600 and 2900 t/h. Feed to the circuit is nominally <50 mm from secondary closed-circuit crushing. The product of the wet screens is < 5 mm, P80 between 2.5 and 3.0 mm. Grinding is done in four 12 MW ball mills.

Earlier feasibility studies had identified that two (2) 40' SAG mills, each 22 MW, and four (4) ball mills, each 12 MW, as well as three (3) 750 kW pebble crushers, would be required. Four (4) 750 kW secondary crushers are used in the HPGR circuit.

Polysius AG
Graf-Galen-Straße 17,
D-59269 Beckum-Neubeckum, Germany
Phone: +49 2525 99-0
Telefax: +49 2525 99-2100
E-Mail: polysius@thyssenkrupp.com
Internet: www.polysius.com

The savings are not only in power, but also in the elimination of expensive grinding media. Long term safety risks associated with SAG mill liner replacement were also eliminated. (1)

SABC circuits are sensitive to variations in size distribution and hardness of the ore. HPGR circuits are far less sensitive to these variations. There are other issues associated with SABC circuits which most trade-off studies fail to mention. These include the following:
- segregation on coarse ore stockpiles which results in SAG mills always receiving different size distributions;
- pebble crushing circuits operating with wide fluctuations in feed and in contact with tramp metal / grinding media add to the complexity of the circuits. Thus one of the benefits – simplicity of the SAB Circuit – is gone.
- SAG mill screens that are at the limits of their capacities when handling the output of the larger SAG mills.

Flexibility to adjust to harder ores is lower for SAG mill circuits than it is for HPGR circuits, and the upside potential is limited, often by constraints in primary crushing. A further advantage is that HPGRs can be designed with a significant catch-up capacity without affecting the specific energy consumption, wear life or product size distribution.

Finally SAG mills have longer lead times, risks with larger castings, and far longer installation times. The ramp-up time to full production is shorter for HPGRs as indicated above.

Wear has been the major impediment to acceptance of HPGRs into hard rock mining. Wear to the sides of the rolls and welding of the edges has virtually been eliminated. To protect the roll surfaces from wear, each roll is embedded with tungsten carbide wear resistant studs. Wear lives have been steadily improving. It is anticipated that the newest set of studs will have a wear life of close to 6000h.


HPGR feed chute, load cells, feed control gates, and diverter by-pass chute.

The units operate with one fixed position roll and a floating roll to which grinding pressure is applied. The operating pressure is 120-130 bars and average operating gap is 60-70 mm.

The HPGR feed chute system is installed with metal detection and a diverter bypass chute to avoid tramp metal entering the HPGR. The feed chute is on load cells to help maintain a constant level for choke feeding the rolls. There are also feed control gates that help position the feed in the rolls and prevent differential power draw.

Main comments from the operators have been that the production capacity can be maintained even with fewer (3) HPGRs, and that swings in throughput are avoided.

Whereas Cerro Verde was a milestone in the application of HPGRs to hard rock mining, it was quickly followed by another “first” in copper-gold.[(2)] PT Freeport Indonesia installed two (2) HPGRs, rolls 2.0 m diameter x 1.5 m wide, each powered by 2 x 1800 kW motors, at their C1 and C2 concentrators in 2007. These employ conventional three-stage crushing. Throughput is expected to be up to 80,000 t/d. The primary purpose was to reduce the flotation feed size and to increase copper and gold production by 4-5%. The units were set up for quaternary crushing duty, taking a feed that was already 80% < 7.5 mm and reducing this to a P80 size of 3-4 mm for ball mill grinding.


PT Freeport Indonesia’s HPGRs with feed and by-pass chutes

The main drivers were a lower capital cost than a comparable ball mill option, the small footprint of the HPGRs, and the fact that the HPGRs could be commissioned 6 months ahead of the ball mills. The latter is becoming increasingly important in today’s volatile markets.

The upside potential of the HPGRs also fit their strategic plan to be able to handle future capacity increases.

One feature of the HPGR circuit is that they are able to recycle part of the product to reduce the fineness even more. Despite the fine product produced by the HPGRs, there have been no detrimental effects in flotation due to overgrinding.

Too many fines can lead to flow problems in fine ore bins particularly at higher moisture levels. Preparations were made to overcome these, but the problems did not occur.

Wear on these Freeport units has been quite low. Over 16 millions tons have been processed on each unit in the period to end of August 2009. Most recent measurements indicate a projected wear life of > 20,000 h. This appears largely to be due to the fact that the feed is much finer than the operating gap, thus minimizing ore-to-metal contact.

A third large HPGR was commissioned in the 1st Q 2008 for a very hard Platreef platinum ore in South Africa. Bond Work Index 23-27 kWh/t. The rolls are 2.2 m in diam. x 1.6 m wide, and is located at the Anglo Platinum Mogalakwena North Concentrator. Feed < 65 mm. Product < 8 mm, 50% < 1 mm. Flowsheet includes dry screening. The technology was selected over AG/SAG milling after a 7 month on-site trial had demonstrated 96% availability.(3)

HPGR Polycom 22/16 at Mogalakwena plant

The company has had more than 10 years experience in operating AG mills. From the outset variation in the ore due to rock characteristics and differences in mine fragmentation resulted in operational instabilities and varying monthly production levels. In-circuit-crushing was installed to remedy the situation. The ore was so hard that at times the crushers could not keep up and the stock of uncrushed ore was building. A pilot HPGR was leased, and run for 7 months treating in excess of 185,000 tonnes of Platreef ore. At the end of the testing period, 1000-ton batches of very abrasive UG2 and Merensky ore were run on the machine. The tests were successful demonstrating low wear, high reliability, and producing size distributions that were much finer than those obtained from conventional crushing of the material. Most importantly, the operating and maintenance staff overcame their initial scepticism and became supportive of HPGR technology.

The HPGR operates at a rate of 2100-2400 t/h. Circulating load is between 90 and 120 %.(4) The design capacity of the whole circuit was 900 t/h, with the HPGR specified at 1200 t/h, giving a catch-up rate of 300 t/h. The HPGR is not fitted with VSD drives, but the feed conveyor is fitted with these drives to maintain a constant level in the feed hopper. Predicted wear life of the rolls is > 20,000 h.

Following the successful pilot plant runs on UG2 and Merensky ores, Northam Platinum installed a similar size unit in its UG2 concentrator in South Africa. (UG2 is a high chromium bearing ore.) [5]

Northam UG2 Plant Polycom 09/06-0

The plant was commissioned in June of 2008. The rolls are 0.95 m in diam. x 0.65 m wide; installed power is 2 x 200 kW; throughput 160-200 t/h; feed < 32 mm; product 75% < 1 mm.

The objectives were to increase production, increase product fineness and reduce chrome content in the concentrate. (Chrome interferes with the recovery of PGMs in smelting).

It achieved all of these aims with a 20-30% reduction in grinding energy and a 4% increase in recovery resulting in a payback in 90 days.

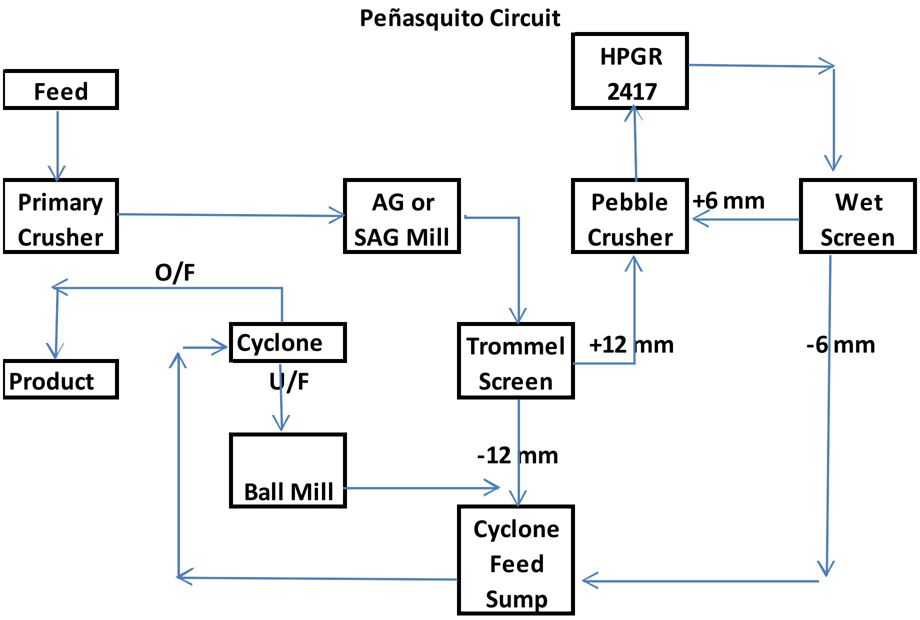
Newmont is currently commissioning four (4) large HPGR units at Boddington Gold Mines in Australia. The roll are 2.4 m in diameter x 1.65 m wide. Each unit is powered by 2 x 2800 kW variable speed drive units. The plant will have a capacity of 35 Mtpa.

The decision for Boddington to go ahead with HPGRs was in large part due to the successful demonstration of HPGR technology at the Newmont Lone Tree Plant in 2003.[6]

The ore was characterized as being very hard (JK Tech index A x b = 27) with little variability within the deposit. [7] Criteria often given for selecting HPGRs over SAG mills are an A x b index < 40, consistent hardness, and a large deposit. Boddington is certainly a large deposit. A trade-off study showed that while capital costs were a little higher for a HPGR circuit, 7%, vs a SABC circuit, the operating costs and risks were significantly lower.[8]

Boddington will have a capacity 108,000 t/d, and the HPGRs will be working in closed-circuit with wet screening. However the layout is different from Cerro Verde. The crushers and HPGRs are all in a line using a forward crushing scheme. The Cerro Verde layout is more compact and uses conventional screening before secondary crushing.

The newest HPGR coming to hard rock mining will be at Peñasquito in Mexico. The unit, with rolls 2.4 m diameter x 1.65 m wide, will be installed in a SABC circuit to process crushed pebbles. It will be the first application of HPGRs in pebble crushing in the non-ferrous minerals industry. (A small unit was installed in pebble crushing in an iron ore plant in the US in 1996, and proved its worth.)[9]



Peñasquito circuit flowsheet.

The unit will have an installed power of 6000 kW, and is expected to increase the capacity of two SABC circuits by 30% (from 100,000 tpd to 130,000 tpd) for an outlay of 4.8 kWh/t.[(10)]

The ore has been classed as hard, Bond WI 13.5, but low in abrasiveness. The pebbles represent the harder portion of the ore. The larger diameter rolls were selected to minimize the risk of damage from tramp metal / grinding balls coming from the SAG mill.

The HPGR product will be wet screened on 6 mm; the undersize will be fed to the ball mill cyclone feed sump, the oversize will be returned to the pebble crushers.

Conclusions

Examples have been given of different applications of HPGRs in hard rock mining:
HPGRs used in tertiary crushing duty, in quaternary duty, with recycle, with wet screening and with dry screening, as alternatives to SAG mills and complimentary to SAG mills in pebble crushing duty.

It has been shown that even on a smaller scale, installing HPGRs in existing operations can increase production and reduce operating costs within a relatively short payback period.

An important feature of HPGRs is that they can maintain production even as the rolls wear.

The sheer proliferation of these machines in such a short time is testimony to the world-wide acceptance of HPGR technology.

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