Mount Polley Mill:

Trade-off study on the introduction of HPGR technology in copper-gold processing
Trade-off study to introduce HPGR technology to Mount Polley copper-gold mill, executed on behalf of Imperial Metals Corporation, 2007

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Cover photos; Mount Polley copper concentrate (Photo: Imperial Metals Corporation); Shipment of concentrate from Mount Polley at the Vancouver wharves (2005) (Source: www.imperialmetals.com)
1. ABOUT THE CLIENT

Imperial Metals Corporation (Imperial) is a Canadian mining company based in Vancouver, British Columbia. The company is active in the acquisition, exploration, development, mining and production of base and precious metals.

2. BACKGROUND TO THE PROJECT

Mount Polley Mine:

Mount Polley is an open pit copper/gold mine in British Columbia, wholly owned by Imperial. It produces on average 20,000 tonnes per day. In 2010, 77% of the mill feed was supplied by the Springer pit, but in 2011 virtually all mill feed will be sourced there, with the balance from the Southeast and Pond zone pits (which were completed in 2010).

The property covers 18,321 hectares, which consists of five mining leases totaling 1,867 hectares, and 43 mineral claims encompassing 16,455 hectares.

Existing Mill capacity:

Run of Mine (ROM) ore from the pit is delivered by haul trucks to the primary gyratory crusher followed by secondary and tertiary crushing and screening facilities. The multi-tube feeders withdraw crushed ore (-13 mm) from the fine ore stockpile onto the rod mills feed conveyor. The grinding circuit consists of two rod and ball mills followed by pebble mills. The existing mill capacity is 20,000 t/d with a reported availability of 92%.

Mount Polley concentrates are trucked to facilities at the Port of Vancouver, and shipped to overseas smelters or transported by rail to smelters in North America. Ongoing exploration at Mount Polley in 2011 will continue to focus on defining underground higher grade mineralization, and further testing of the mineralized zones in the vicinity of the Springer pit.

Expansion of Mill capacity:

Imperial intends to expand the mill capacity to a rate of 30,000 t/d. Based on potential economic and technical benefits of using High Pressure Grinding Rolls (HPGR) for similar projects, Imperial shipped approximately 5 tonnes of Mount Polley ore to the pilot plant facilities of Köppern Equipment Inc. (Köppern) in Australia for testing. In November 2006, Imperial contracted Köppern to develop the HPGR pilot tests. The test results showed that the ore supplied by Imperial responds very well to high-pressure comminution.

In March 2007, Imperial commissioned Wardrop Engineering (now Tetra Tech)¹ to develop a HPGR scoping study for the comminution circuit. The Tetra Tech study is based on historical information provided by Imperial and the aforementioned HPGR test results from Köppern.

¹ Effective Oct. 3, 2011, Wardrop Engineering Inc. changed its name to Tetra Tech WEI Inc., after the outright acquisition of the company by Tetra Tech Inc. in 2009.
4. WHAT SETS THE MOUNT POLLEY MILL PROJECT APART?

The type of ore and the capabilities of crushing and conveying technologies are intrinsically linked, and the correct match of technology to ore body for a specific operation has a significant impact on economics and the environment. Energy savings can be obtained through the use of new technologies such as HPGR, if it is suitable for the specific type of ore and mill capacity requirements. This project is differentiated by the identification and selection of HPGR technology but also because of the high level of hardness of the rock. This, and the fact that it is a brownfields project, in existence since about 1996, compounded the complexity of the trade-off studies.

3. INDUSTRY SNAPSHOT

Copper-gold mining

In byproduct gold mining, gold is also produced in mines in which it is not the principal product. Large copper mines often recover considerable amounts of gold and other metals along with the copper. The largest-producing gold mine in the world, the Grasberg mine in Papua, Indonesia, is primarily a copper mine.

Canadian copper-production complexes usually process the concentrate from several mines. British Columbia produces the most copper concentrate in Canada, although it has no copper-production facilities, and therefore exports some of its concentrates directly and processes the rest at smelters in eastern Canada. Copper is also mined in Flin Flon, Manitoba; Sudbury and Timmins, Ontario; and near Rouyn-Noranda, Quebec. It is processed at complexes near all of these mining locations. (http://atlas.nrcan.gc.ca)

HPGR technology

HPGR technology was originally developed and applied in the cement industry. The technology was introduced into the mining industry in the early 1980s with the first HPGRs being used for the crushing of kimberlite in diamond mines. The application and advantages of using these grinding roles to extract diamonds is well established. HPGR technology was also successfully introduced and applied in the iron ore industry and for the crushing of limestone.

Mining companies are now beginning to incorporate HPGR technology and Phelps Dodge (now Freeport-McMoRan Copper & Gold Inc.) is an example of a mining company that has taken the lead in introducing HPGR at Cerro Verde mine in Peru, in 2006. The circuit at Cerro Verde incorporates four HPGR units (2.4 m diameter x 1.6 m wide, 5,000 kW, processing 2,500 t/h), instead of traditional SAG mill circuit. Freeport-McMoRan’s Grasberg mine in Irian Jaya, Indonesia, uses two HPGR units (2.0 m diameter x 1.8 m wide, 3,600 kW, processing 1,450 t/h). In 2010 ABB successfully commissioned the world’s largest HPGR drive system for Newmont’s Boddington gold-copper mine expansion project in Western Australia. By optimising the grinding process, ABB’s ACS1000 drives will help the plant reduce its energy consumption. Other mining companies that have taken an early lead in utilizing HPGR technology is De Beers at its Victor diamond mine in Canada, Anglo American Platinum at its Mogalakwena operation, and Assmang, at its Khumani iron ore mine.
5. PROJECT MILESTONES

- July 8, 2005: Upon re-starting the Mount Polley Mine, a total of 11,500 tonnes of Mount Polley Concentrate was loaded at Vancouver Wharves in North Vancouver, B.C.

- 2006: First full year of production from the Mount Polley Mine after restart of milling operations on March 8, 2005.

- July 2006: The newly developed Wight Pit became the major source of mill feed. Both copper and gold recoveries of 86.7% and 72% respectively, were the highest achieved to date.

- 2007, Quarter 3: Improvements to the crushing plant were completed, including an increase in size of the primary feeders to reduce the impact of winter conditions on crusher operations.

- 2008: Mining in the Bell pit was completed, and mining in the Wight pit was expected to be completed near year end. The Springer pit was scheduled to supply the majority of mill feed in 2009.

- 2009, Quarter 3: The majority of ore delivered to the mill was from the Springer pit, along with smaller amounts from the Southeast and Wight pits.

- 2010, Quarter 3: Mill throughput averaged 22,563 tonnes per day, with gold production for the 2010 nine month period both increased slightly from the same period in 2009. A plant was being installed in the Mount Polley concentrator, which is designed to recover fine magnetite from the tailings stream, which can be sold as dense media for use in coal wash plants. This new addition to the plant was expected to be completed during the 2010 fourth quarter.

6. LOCATION

Mount Polley Mine is located 8 km southwest of Likely and 100 km (by road) northeast of Williams Lake, British Columbia, Canada.

7. PROJECT SCOPE

The grinding circuit of the Mount Polley consists of two rod and ball mills followed by pebble mills, with a capacity of 20,000 t/d and reported availability of 92%. In November 2006, IMC began evaluating methods to increase the Mount Polley production rates to 30,000 tonnes per day. One potential option was utilizing HPGR technology.

Köppern conducted comminution tests, evaluation of the response of the tested ore to the HPGR process, and equipment sizing. The grinding and feed variable parameters were tested and the influence of process parameters on comminution performance was determined through analysis. Testwork results showed that the tested ore responds well to high-pressure comminution with a large size reduction and high throughput.

“...The application of High Pressure Grinding Rolls (HPGR), especially as a replacement for the conventional SAG milling, is receiving a great deal of interest with several of our mining clients [who are] considering the use of this process to reduce energy consumption and costs.”

- Jake Alexander, Director: India Operations, Tetra Tech, Vancouver
“Based on my experience, each project that we do is as unique as the ore involved, having its own characteristics in terms of hardness, abrasiveness, genesis, clay content, typography, moisture, etc. – and therefore studies and recommendations cannot simply be replicated for generic solutions. Regardless of how much we have learned over the past decade, and how much information is out there in the industry, each case and each project is still inimitable, as distinctive as the rock we work with.”

- Hassan Ghaffari, P.Eng., Manager, Metallurgy, Mining and Minerals, Tetra Tech, Vancouver

7. PROJECT SCOPE (CONTINUED)

In March 2007, Imperial commissioned Wardrop Engineering (now Tetra Tech) to develop a scoping study into the use of HPGR in the comminution circuit to reduce the feed size produced by the tertiary crushers, in order that the existing rod mills could be converted to ball mills; thus achieving the 30,000 tonnes per day production. The study was based on the Köppern test report (“High Pressure Comminution Testwork Report for Processing of Copper/Gold Ore from Mount Polley Deposit IMC.”), and the proposed plant capacity expansion. Tetra Tech made a site visit to collect data, and reviewed Köppern’s test work results and data provided by suppliers as bases for this scoping study and cost estimation report.

8. OUTCOMES

Based on the study, and the suitability of ore to high-pressure comminution, it has been shown that the introduction of the HPGR into the process flow sheet, and converting the existing rod mills to ball mills, will allow the plant capacity to increase by 50%, and availability of the HPGR to be at 95%. The comminution circuit can be expanded to 30,000 t/d with minimal impact to the ongoing operation.

Suitability of HPGR to ore type

The HPGR consists of a pair of counter rotating rolls, one fixed and the other floating. The feed is introduced to the gap in between the rolls and is crushed by the mechanism of inter-particle breakage. The grinding force applied to the crushing zone is controlled by a hydro-pneumatic spring on the floating roll. Speeds of the rolls are also adjustable to obtain optimum grinding conditions. (Crushing and Grinding: Comminution Concerns, In: International Mining, Oct. 2008, pp.20, 22)

Imperial had shipped approximately 5 tonnes of Mount Polley’s ore sample (-50 mm) to the pilot plant facilities where thirteen high pressure grinding roll tests were performed. In these tests, a range of grinding and feed variable parameters including specific grinding force, roller speed, feed top size, moisture content, and edge recycle tests were tested to evaluate the response of ore to the HPGR process. The average P80 and P50 percentage passing sizes for the final three cycles were 5.97 mm and 1.69 mm, respectively. Based on Köppern’s pilot test results, the average gross specific energy requirement is 2.19 kWh/t with a specific throughput of 239 t/hm² for the last three cycles.
8. OUTCOMES (CONTINUED)

The Köppern test results from the existing plant operation showed that Mount Polley’s ore has an average Ball Bond Work Index (Wi) of 17.5 kWh/t. Due to this characteristic, as well as other features such as lower moisture and lower clay content, this ore was deemed suitable for high-pressure comminution in an industrial application.

HPGR upsides

HPGR’s advantages outweigh the limited disadvantages of potentially increasing the initial capital costs, materials handling and dust control. The benefits of using HPGR in this expansion project are remarkable when considering HPGR as a quaternary crusher. The major benefits are large savings in energy costs, reduced grinding media consumption and operating costs, smaller footprint, faster equipment delivery schedules and finer product.

It is estimated that energy savings of up to 20%, and 10 to 20% savings in overall operating costs are possible, depending on the ore type and application. More savings are possible when additional HPGR stages are incorporated in grinding circuits. A further potential benefit of inter-particle crushing is improved recoveries from downstream processing as a result of micro-cracking occurring within the particles.

Further research in HPGR

While HPGR technology has been used successfully in diamonds, iron ore and limestone processing, over the past few years major advances have been made in wear protection technologies that have been applied to the roll surfaces (such as the use of studs, segments, edge protection inserts and advanced construction materials) which as made HPGR more suitable to hard rock mining applications. The wear rate test and the impact of high pressure comminution on ball mill unit energy consumption are underway and will be used in future studies.

Flowsheet development for Mill expansion

The flowsheet design was based on the information received from IMC, data collected from the site visit, and Köppern’s HPGR pilot plant testwork results. The following main unit operations are included in the expanded comminution circuit:

- The existing primary gyratory crusher is used followed by secondary and tertiary cone crushers
- Two parallel HPGR crushers - 35 mm material from fine ore stockpile
- Two new conveyors to feed the HPGR
- Added one new conveyor to feed the fine ore stockpile
- Two new pumps
- Two new cyclopacks installed in the grinding building that are fed from HPGR product through pumps
- The existing rod mills converted to ball mills
- Two existing ball mills

"In a trade-off study of this type, the two most important markers of success are firstly, whether we – as independent advisors, not equipment suppliers – fully understand the characteristics of the materials we are dealing with, and secondly, whether we have delivered proof of concept. Only once we have fully investigated all the options, would we incorporate HPGR into the design. Detailed work on all the test results gives us the confidence to go ahead with our proposals and guarantee a satisfactory outcome for the client."

- Hassan Ghaffari, P.Eng., Manager, Metallurgy, Mining and Minerals, Tetra Tech, Vancouver
8. OUTCOMES (CONTINUED)

- Three existing pebble mills
- The existing regrinding pebble mill converted to a primary ball mill.

All of the existing conveyors in the comminution circuit were reviewed and the modifications including speed change, belt loading percentage, and additional power requirements were determined. Also, the new conveyors to be added to the expansion circuit were determined.

Recommendations

Based on the findings of this scoping study, Tetra Tech recommended the following:

- Upgrading this study to a feasibility study to finalize the capital and operating costs, followed by detailed engineering, procurement, construction, and commissioning as warranted.
- If the comminution circuit is expanded, the remaining facilities should be updated and expanded accordingly.

Subsequent developments

Mount Polley Mine has not implemented further work based on the results of the scoping study economics. The mine life at the time of the study and the resultant capital costs to implement HPGR did not support proceeding to the feasibility stage.

References

All statements about this project, including site maps and photos, in this document have been sourced from www.imperialmetals.com, and internal company documentation, unless stated otherwise.

Additional resources:

- Caulfield, P., Properties that keep on giving, Mineral Exploration, Spring 2011, pp. 18, 19
- Imperial Metals Corporation: Mount Polley Mine Property – HPGR Scoping Study 02/08/2007 0753220100-REP-R0001-01, p. 3-1

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