Multiple-pass High Pressure Grinding Rolls Circuits

M. Hilden and M. Powell
University of Queensland, JKMRC, QLD

Introduction, Background and Objectives

High Pressure Grinding Rolls (HPGR) are widely considered to be more energy efficient devices for comminuting rock than tumbling mills such as SAG mills. Recently, HPGR have been installed and commissioned at Cerro Verde (Peru), Mogolokwane (South Africa), and Freeport (Indonesia) with reported energy savings of around 19% over more conventional grinding routes [1].

To date, HPGR have been installed as single unit, either in open circuit or closed circuit with a screen. A single HPGR unit is typically limited to around 3 kWh/t, compared with SAG mills which may have energy inputs exceeding 10 kWh/t, and therefore despite being less efficient can generate a finer product.

This project aims to determine whether a series of HPGR units could be used to perform most of the grinding duty in a process plant, increasing the amount of breakage performed in these highly efficient devices. Such a circuit could substantially reduce the energy and grinding media used in milling circuits and therefore reduce the carbon footprint of new processing plants.

Methodology / Experimental Technique

Three ore samples have been tested to date. The samples were a hard copper-gold ore, a softer lead-zinc sulphide ore, and the third was a porphyry copper ore. The samples were crushed to -32 mm top-size and processed in a three-pass HPGR circuit (Figure 1).

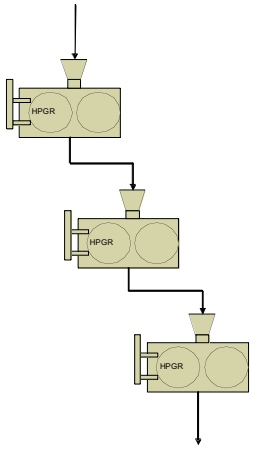

Figure 1: *Three HPGR in series.*

Test work was carried out on two large pilot-scale Köppern HPGRs at AMMTEC, Perth. The first two samples were tested using 0.22 m (W) x 0.75 m (D) rolls in July 2007. The third sample was tested using a newer 0.25 m (W) x 1.0 m (D) HPGR (Figure 2) in March 2008.

Figure 2: *Köppern's Andrew Gardula and JKMRC's Malcolm Powell discussing the pilot-scale HPGR at AMMTEC Perth.*

The third sample was also tested in a wide range of circuit configurations that included screening between passes. Test work was also carried out using one or two passes with the Köppern HPRG with subsequent passes carried out at CSIRO Pinjarra Hills using a laboratory-scale HPGR 0.10 m (w) x 0.25 m (D). In each case, up to three passes of the HPGR were used.

The energy consumption and product size was measured for each stage in the flow sheets to allow energy efficiency of each circuit to be determined.

Key Results / Findings

The feed and product sizes from the samples tested to data show that the three-HPGR circuit produces a broad product size distribution, but also that the magnitude of size reduction reduces with subsequent passes. Two passes were found to be effective; however the third pass continues to generate fines without substantially reducing the top size. The result is a flatter or broader product size distribution as shown in Figure 3.

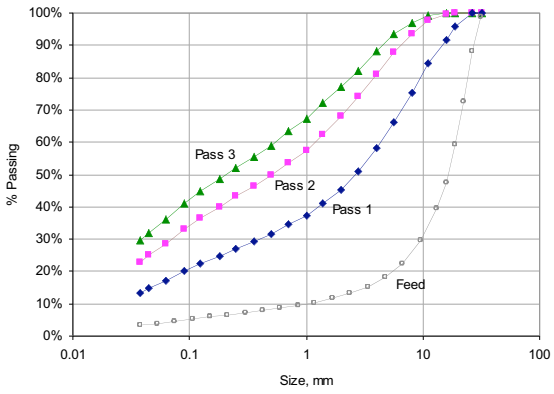

Figure 3: *Product sizing for the three-stage circuit.*

A number of three-stage circuit HPGR configurations were compared with the above three-pass HPGR circuit. Two approaches were found to be effective in generating a steeper product size distribution:

1. Removing excess fines from the feed to the HPGR (Figure 4a), and
2. Using a smaller diameter rolls in the second and/or third pass (Figure 4b).

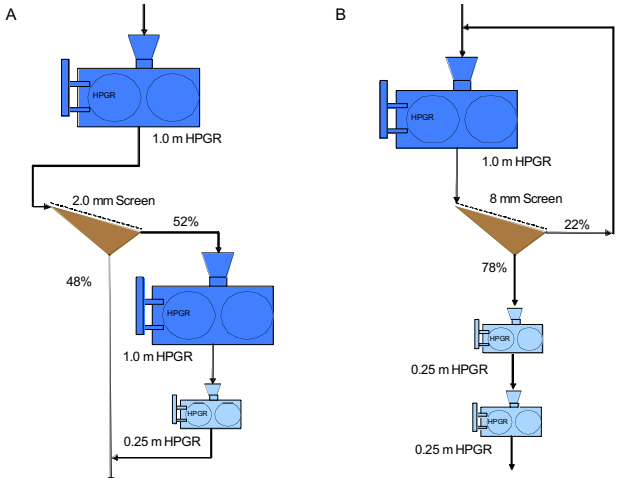

Figure 4: Two of the alternative flow sheets tested.

As shown in Table 1, these circuits produce a similar-sized product using less energy compared with three passes in the 1.0 m rolls. In the case of flow sheet 4b, just two HPGR passes are needed to grind to an equivalent product fineness (measured using the 80% passing size, P80, and the quantity of -150 microns fines generated), and uses 33% less energy.

Table 1: Comparison of various three-pass HPGR circuits.

	Pass 1	Pass 2	Pass 3
	Triple-pass circuit Fig 1.		
P80, um	9391	3788	2414
% -150um	24%	38%	47%
Energy, kWh/t	2.77	5.23	7.53
	Modified Circuit Fig 4a.		
P80, um	8804	2824	1425
% -150um	22%	35%	45%
Energy, kWh/t	2.83	4.13	5.48
	Modified Circuit Fig 4b.		
P80, um	4710	1764	1195
% -150um	27%	46%	53%
Energy, kWh/t	3.23	5.03	5.83

Highlights / Benefits

- Test work confirms that the HPGR can be used in series to efficiently generate a very fine product. After three passes, around half of the product can be made into final flotation feed size.
- Two flow sheet modifications further improve the performance of the three-stage HPGR circuit and use less energy, albeit using a potentially more complex flow sheet.

Conclusions and Future Direction

This work has shown that a multi-pass HPGR circuit can generate a high proportion of fines, but only two passes appear to be beneficial without either a classification stage or a reduction in roll diameter. One or two additional samples will be tested in coming months.

Acknowledgements

This work was carried out under the auspice of the Centre for Sustainable Resource Processing, which is established and supported under the Australian Government's Cooperative Research Centres Program. The large-scale test work was carried out with the assistance of Köppern Machinery Australia and the small-scale HPGR test work was carried out by Steve Suthers of CSIRO, Pinjarra Hills.

References

1. C. M. Rule, I. Smit, A. J. Cope, and G. A. Humphries, "Commissioning of the Polycom 2.2/1.6 5.6MW HPGR at Anglo Platinum's new Mogalakwena North Concentrator," presented at Comminution 08, Falmouth, 2008.