Case Study: Elimination of tumbling mills to improve process, energy and cost efficiency of comminution circuits – CEEC award winning paper.

Summarised by G.R. Ballantyne and M. J Daniel

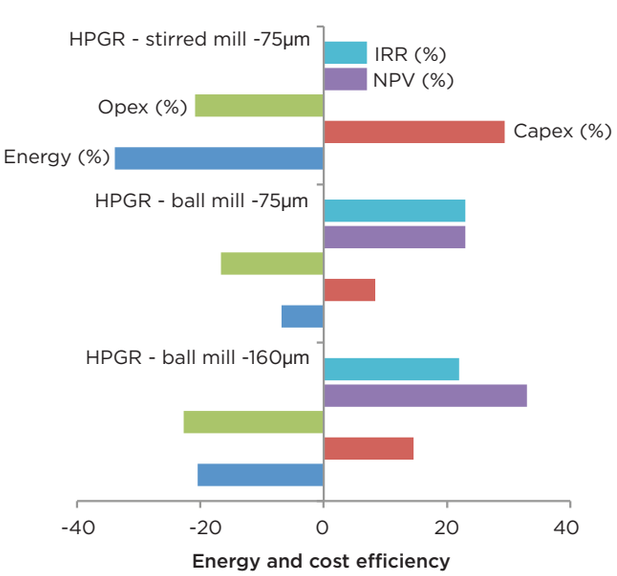
The energy efficiency debate in comminution is an ongoing one, with several different points of reference. A recent Coalition of Eco-Efficient Comminution (CEEC) award-winning paper by Wang et al 2013, adds to this debate. Wang, Nadolski[1] presented an analysis of energy and cost efficiency of HPGR-based circuits. The paper for 2013 medal is for the most outstanding research and field work on beneficial strategies for eco-efficient comminution. Wang's medal-award winning paper is summarised below - the full article can be found on the CEEC website.

The SABC circuit at the Huckleberry copper-molybdenum porphyry mine in Canada was used as the basis for comparison. A circuit simulation was used to describe units of operation within the circuit and was established using measured feed and product particle size distributions. The target grind size for this circuit was a P_{80} of 160µm. To allow comparison to the HPGR/stirred mill circuit, they were also simulated to obtain a P_{80} of 75µm.

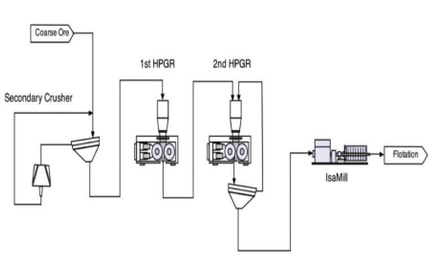
Two laboratory pilot scale HPGR based circuits with common secondary crushing equipment (P_{80} of 32mm) were assessed, namely: single-stage HPGR followed by two ball mills, and two-stage HPGR combined with three IsaMills.

Ore samples were taken from the SAG feed belt at the Huckleberry mine. Two parameters were used to scale up the performance of the HPGR: edge to centre ratio of 1:9 and a motor efficiency of 83 per cent. Bond mill grindability tests were conducted on SAG circuit feed and HPGR product samples to estimate the power requirements and size of the ball milling circuits. The lab IsaMill tests were conducted on minus 710µm HPGR product with large diameter ceramic grinding media (6 to 2 mm). Energy requirements were estimated from lab scale signature plots.

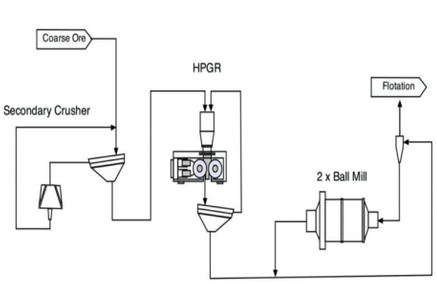
• Energy efficiency Comparisons



• HPGR and Stirred Mills Flowsheet



• HPGR and Ball Mills Flowsheet



Circuit energy requirements were determined and found to require 7-34 % less energy than the industrial scale SAG based circuit (see figure above). These results demonstrate that HPGR's are more energy efficient than conventional tumbling mills. An economic trade-off was conducted using net present value (NPV) with a discount rate of 5% and a 15 year mine life. Estimates of the capital and operating costs were at the scoping level stage (accuracy of ±50%).

Energy was responsible for approximately 30% of operating costs across all circuit designs. Although the capital costs for the HPGR circuits were greater than the equivalent SAG based circuit, the reduced operating costs resulted

in cost advantages in terms of NPV and internal rates of return (IRR) The energy and operating costs advantage of the HPGR-ball mill circuits was found to be not as large as the HPGR-stirred mill circuit, however, the lower capital costs resulted in greater improvements in NPV over the SAG circuits.

A number of other studies have assessed the energy efficiency of HPGR over SAG circuits. Daniel et al[2] assessed efficiency, economics, energy and emissions in a paper entitled "Emerging criteria for comminution circuit decision making". Rosario and Hall[3] found for circuit P_{80} between 140 and 180µm, HPGR-ball mill circuits use between 7.7 and 18.4 % less energy than the corresponding SABC circuits. Amelunxen and Meadows[4] investigated the relationship between rock competence and HPGR efficiency. For a P_{80} of 180µm, HPGR was only found to be more economically viable than standard SABC circuits when the ore hardness is greater than 118 (minutes-SPI). Hilden and Suthers[5] found that the measure of product quality played a major role in the determination of grinding efficiency and this should be chosen carefully.

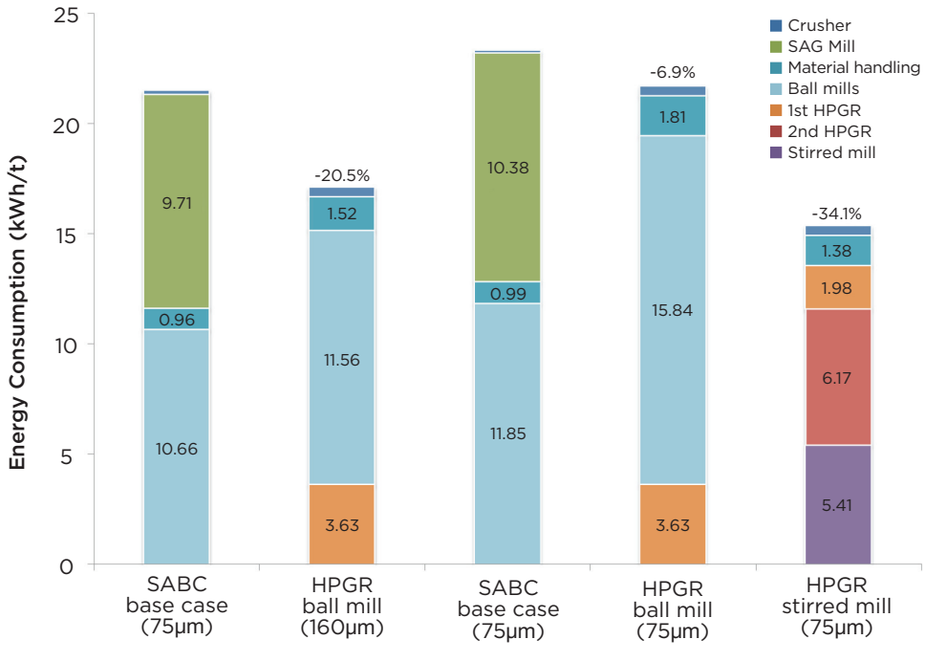


Figure 2 - Comparison of total circuit energy requirement[7]

HPGR circuits are generally not only more energy efficient than the corresponding SAG based circuit design, the elimination of steel grinding media helps to counteract the increased capital cost to result in increased economic viability[1]. HPGR and stirred milling are also more resilient to variations in ore hardness when compared to SAG mills[1]. However, it should also be noted that the cost effectiveness of HPGR applications is linked to ore hardness and both increased roll wear rates and reduced machine availability can limit the cost effectiveness of HPGR in practice.[6]

[1]Wang, C., Nadolski, S., Mejia, O., Drozdiak, J., Klein, B., Canadian Mineral Processors Operators Conference. 2013. Ottawa, Ontario. [2]Daniel, M.J.; Lane, G.; McLean, E. IMPC 2010. Brisbane, Australia; [3]Rosario, P. and R. Hall, The Journal of the S. African Inst. Mining and Metallurgy, 2010. 110: p. 117-123; [4]Amelunxen, P. and D. Meadows, Minerals & Metallurgical Processing, 2011. 28(1): p. 1-7; [5]Hilden, M. and S. Suthers. IMPC 2010. Brisbane, Australia; [6]Hart, S., Parker, B., Rees, T., Manesh, A., Mcgaffin, I., AG and SAG grinding technology 2012: Vancouver, Canada; [7]Wang, C., Nadolski, S., Mejia, O., Drozdiak, J., Klein, B., Canadian Mineral Processors Operators Conference. 2013. Ottawa, Ontario.

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admin@ceecthefuture.org

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