

**FIRST YEAR OF OPERATION OF HPGR AT TROPICANA GOLD MINE –
CASE STUDY**

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ABSTRACT

AngloGold Ashanti selected the high pressure comminution process for their Tropicana Gold Mine in Western Australia. The project was developed by AngloGold Ashanti with the support of Lycopodium Engineering, Perth. Maschinenfabrik Köppern – Germany designed, manufactured and supplied the HPGR. The mine was commissioned during October 2013 and reached full operational capacity within 6 months. This case study describes the challenges faced during the project design stages and first years of operation of the HPGR at the TGM mine site. Pilot plant scale test work summary and HPGR size selection is compared with actual operation results. In summary, the HPGR reached full operational capability within days of commissioning. This operational availability of the HPGR contributed to a quick ramp up of the entire plant that was achieved within weeks of commissioning. By February 2015 the HPGR had reached over 10,000 on load hours in service. The HPGR's high mechanical availability and excellent performance of studded wear protection were the primary contributing factors for the HPGR success.

KEYWORDS

HPGR, high pressure comminution, studded lining

INTRODUCTION

The Tropicana Joint Venture in Western Australia was formed in 2002 between AngloGold Ashanti Australia Ltd (70% and manager) and Independence Group NL (30%).

Tropicana was discovered 330 kilometers East - Northeast of Kalgoorlie in 2005. Exploration identified the deposit at the time containing 5.01 Moz (million ounces) and an Ore Reserve of 3.3 Moz.

The project was approved by the JV partners in November 2010, following a successful bankable feasibility study that was based on open cut mining of the Tropicana and Havana deposits and treatment of 5.5 Mtpa of ore to deliver average gold production of 330,000 to 350,000 ounces per annum over a 10 year mine life. Start-up was targeted for the December 2013 quarter. Forecast capital costs were between AUD\$820-\$845 million.

By early 2012 the 220 km long new access road from Pinjin to the remote site had been completed and construction of the treatment plant was underway. Open pit mining of the Havana Starter Pit began in July 2012 and first ore was sent to the crushing circuit in July 2013. First gold was poured on 26 September 2013, ahead of schedule and on budget, after two and a half years of construction and eight years after the initial discovery.

The processing plant successfully achieved its ramp-up target of 95% plant availability at a throughput rate of 5.8 million tonnes per annum within six months.

PROJECT GENERAL DESCRIPTION AND POTENTIAL

Deposit description

Tropicana Gold Mine is located 330 km East – North-East of Kalgoorlie in Western Australia on the western edge of the Great Victoria Desert.

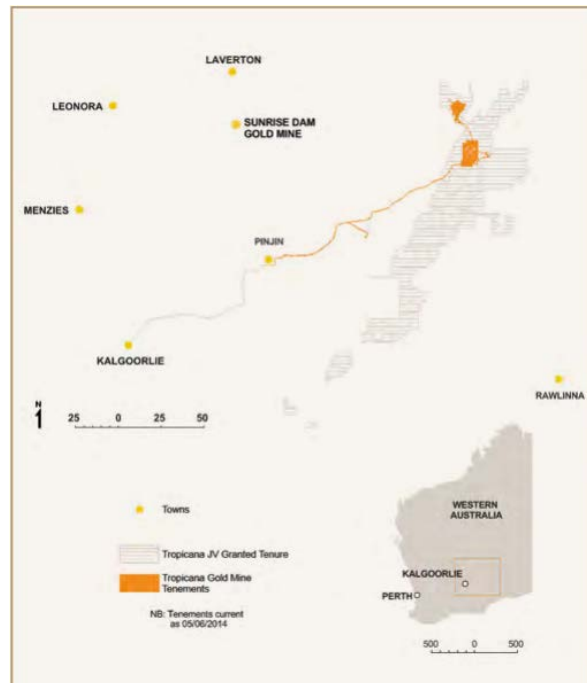


Figure 1 - Tropicana Gold Mine Location (courtesy of Anglo Gold Ashanti)

The ore body mined by Tropicana Gold Mine is composed of Tropicana, Havana, Havana South and Boston Shaker deposits. Currently the mining operations are concentrated on the Havana and Tropicana open pits.

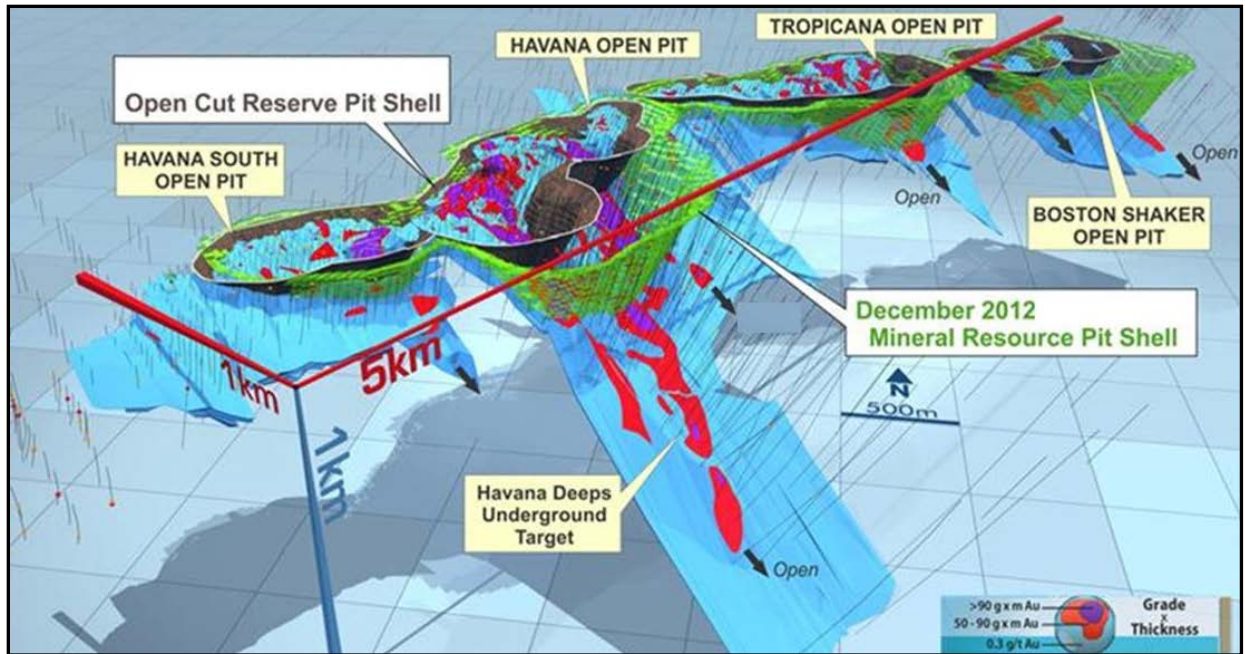


Figure 2 - 3D image of Tropicana Gold Mine deposit (courtesy of Anglo Gold Ashanti – Geology Department)

Project main potential

Tropicana Gold Mine project is based on following parameters:

- Average Annual Production – First 3 years 470 to 490 koz pa
- Average Life-of-Mine Production 330 to 350 koz pa
3.6 Moz in total
- Mine Life +11 years
- Plant Throughput 5.8 Mtpa
- Average Head Grade 2.01 g/t
- Gold Recovery 90.4%
- Ore reserve (as at December 2013) 54.8 Mt

The first gold was poured on 26 September 2013, ahead of schedule and on budget and just under three years after development was approved. As Australia's newest gold mine, Tropicana incorporates innovation from design of its mining and processing systems right through to environmental management.

Following commissioning the ramp-up progressed smoothly with the processing plant achieving 95% availability at design ore throughput levels within six months as planned.

The processing plant is based on a comminution circuit comprising two-stage crushing, a High Pressure Grinding Roll (HPGR) circuit and ball milling together with a conventional CIL circuit.

Decision – Why HPGR?

The decision to incorporate HPGR at the Tropicana Gold Mine (TGM) was made relatively early in the project development stages. The key factors for opting for HPGR were:

- Energy cost
 - HPGR was expected to consume less energy per tonne of ball mill feed compared with conventional solutions
 - It was also expected that ball mill specific energy consumption would be lower (compared with conventional solutions), this resulting from incipient cracks present in BM feed particles
- High mechanical and process availability
- Ease of process control and possibility of process automation
- Fast commissioning and process ramp up
- Lower consumables cost – HPGR wear linings offer long service life and low maintenance cost

The advantages of HPGR technology over conventional SAG milling solution required further investigation via test work using a pilot plant scale HPGR.

PROJECT DESIGN

Process design was a joint effort between AngloGold Ashanti, Independence Group and Lycopodium Engineering. Köppern Machinery Australia participated actively only in the design of the HPGR circuit.

The final process flow-sheet for TGM processing plant included the following:

- Primary crushing – open circuit and stock pile
- Secondary crushing – circuit closed with 42 mm screen
 - Screen underflow reports to HPGR
 - Screen oversize recycled to cone crushers for re-crush
- HPGR – circuit closed with 4 mm screens
 - Screen underflow reports to Ball Mill
 - Screen oversize recycled to HPGR
- Ball Mill product reports to CIL process

The primary prerequisites for the HPGR circuit to operate correctly were:

- Adequate feed rate is required in order to maintain choke feeding of the HPGR
- The moisture content of the HPGR feed material should not exceed the nominated maximum in order to ensure build-up and retention of autogenous protection layer on the roller surface
- Prior to screening the HPGR product must be efficiently de-agglomerated to ensure high screening efficiency and minimize water return to HPGR

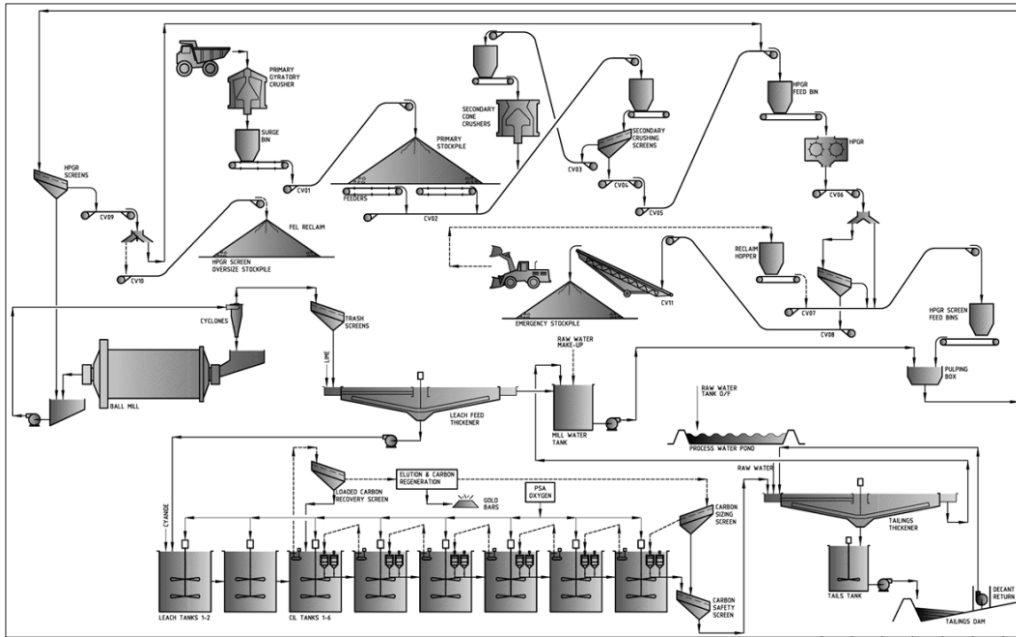


Figure 3 - Process Flow overview (courtesy of Anglo Gold Ashanti)

To achieve efficient HPGR operation a sound understanding of TGM ore behavior in the high pressure comminution process was needed. This understanding could only be gained through HPGR pilot plant test work.

Initial test work arranged by AngloGold Ashanti and Lycopodium Engineering in the beginning of 2010 did not provide adequate data for the final process design and sizing of the HPGR. Additional ore samples were drilled and test work was repeated. This test work provided conclusive data that was subsequently used for final process design.

Test work and main results

The aim of the test work was to assess process performance of the comminution circuit concept. The amenability of HPGRs was assessed through investigation of the following parameters:

- Comminution effect, specific power consumption and process specific throughput as a function of:
 - Specific pressing force
 - HPGR feed moisture content
 - Roller speed
 - HPGR feed top size.

Single pass tests were followed with locked cycle to simulate stable process operation when recycle feed is present in the total HPGR feed. These closed loop test runs provided very valuable information on the expected process specific throughput, power consumption and comminution effect for industrial operation.

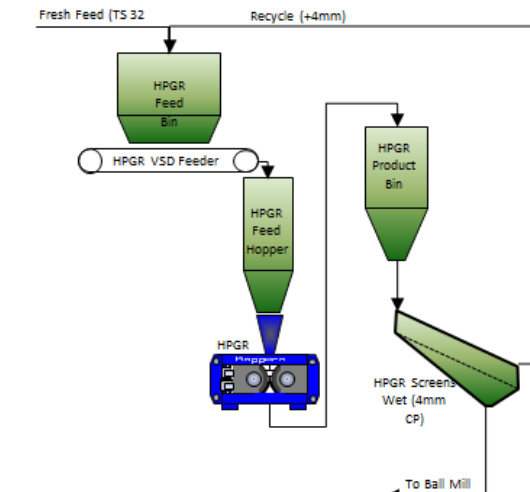


Figure 4 - Process flow sheet investigated during test work and Köppern HPGR Pilot Plant Facility at ALS Global in Balcatta (Perth) – Western Australia

Summary or test results

Typical ore data:

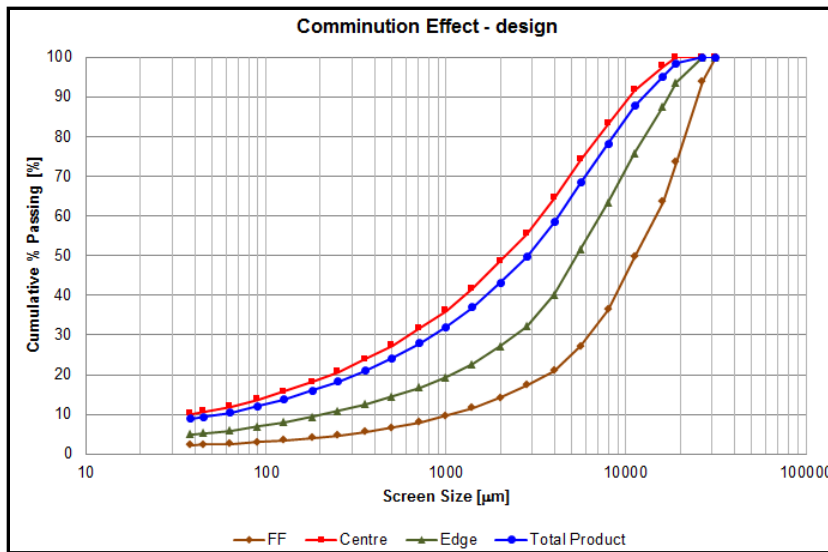
- Ore specific gravity average = 2.82 t/m³
- Bond Ball Mill Work Index average = 17.0 kWh/t
design = 19.6 kWh/t
- Uniaxial Compressive Strength average = 185 MPa
maximum = 250 MPa
- Abrasion index range = 0.31 to 0.38

Single pass pilot plant tests clearly showed that a specific pressing force of 2,800 to 3,200 kN/m² provides best process performance. The comminution effect measured by percentage passing 4 mm (critical size) was very high (58.4%) and achieved at considerably low (1.7 kWh/t) energy expenditure.

An increase in the process specific pressing force to 4,000kN/m² produced very small improvement in comminution effect (~5%) but at the same time specific energy consumption increased by approximately 40%.

In summary, the pilot plant test work gave the following results:

- Process specific throughput constant (m-dot) 270 ts/hm³
- Specific pressing force 3,200 kN/m²
- Specific power consumption 1.7 kWh/t
- PSD results:
- P₈₀ 8.59 mm
- P₅₀ 2.85 mm
- % passing 4mm 58.4%
- % passing 125 □ 3.7%



Reduction Ratio F_{80}/P_{80}

2.5

Reduction Ratio F_{50}/P_{50}

4.0

Figure 5 - Final test work result – comminution effect

The test work results confirmed original Anglo Gold Ashanti / Independence Group confidence that HPGR will provide benefits for the project – high comminution effect and low energy consumption.

Sizing of the HPGR and manufacturing

Sizing of the HPGR is always a challenge as both an over or under- sized machine can spell trouble for the industrial application.

An oversized machine may lead to feed starving conditions in service. In extreme situations this translates to:

- Inability to run continuous process
- Poor comminution effect
- High wear rates
- Increase of specific net energy consumption.

A too small machine will, in addition to the obvious issue of not reaching projected plant throughput, be required to operate at maximum speed for most of the time. This will result in high wear rates and potentially stud breakage during operation.

Tropicana, being a green field project, provided additional challenges:

- Oxide ore that is present near the deposit surface was expected to be soft, clayey and prone to retain high moisture. HPGR operation on this ore could lead to the following issues:
 - Difficulty in maintaining a stable operating gap
 - Generation of strong competent flake and problems with flake de-agglomeration, reduced screening efficiency and excessive water return to the HPGR
- Fresh ore from deeper portions of the deposit was expected to be much more competent and uniform ensuring ease of process control.

Sizing of the machine and its drive train needed to take into account these changing process conditions to ensure that the HPGR can cope with all expected feed conditions. A by-pass chute, whose primary function was to divert tramp metal contaminated ore, could also be used to by-pass the HPGR and feed very soft ore directly to Ball Mill circuit. This design feature would enable plant operation in the worst case scenario when oxide ore cannot be treated in the HPGR.

Project execution milestones:

- | | |
|---------------------------|---|
| • Contract date | 2 nd July 2011 |
| • Factory acceptance Test | 21 st May 2012 |
| • Delivery to Australia | 8 th October 2012 |
| • Installation | 29 th January to 17 th March 2013 |
| • Cold commissioning | 20 th August to 9 th September 2013 |
| • Process commissioning | 24 th September to 10 th October 2013 |

All contract commitments Köppern undertook were met with the HPGR delivered on time and installation and commissioning completed within the contracted time frame and cost.

Table 1 - HPGR size and expected process performance

Description	Unit	Value	Comments
HPGR type		750/20.0 9A 1850 PG1E	
Roller Diameter	mm	2,050	
Working Width	mm	1,850	
Fresh Feed Rate	t/h	688	Dry tonnes
Expected Comminution Efficiency	%	52 %	% passing 4 mm
Expected Screening Efficiency	%	92%	
Nominal Total Throughput	t/h	1,511	
Throughput at Minimum Speed	t/h	1,100	
Throughput at Maximum Speed	t/h	2,200	
Turn Down ratio	%	73%	
Installed Power (main motors)	kW	2 × 2,200	
Wear Protection		Studded Lining with carbide edge protection	
Control system		Köppern design control system inclusive of roller skew and motor torque control	
Operation		24/7	
Warranted mechanical availability	%	95	
Warranted wear life	H	6,000	On load hours
Delivery Time	Months	12	Ex works Germany

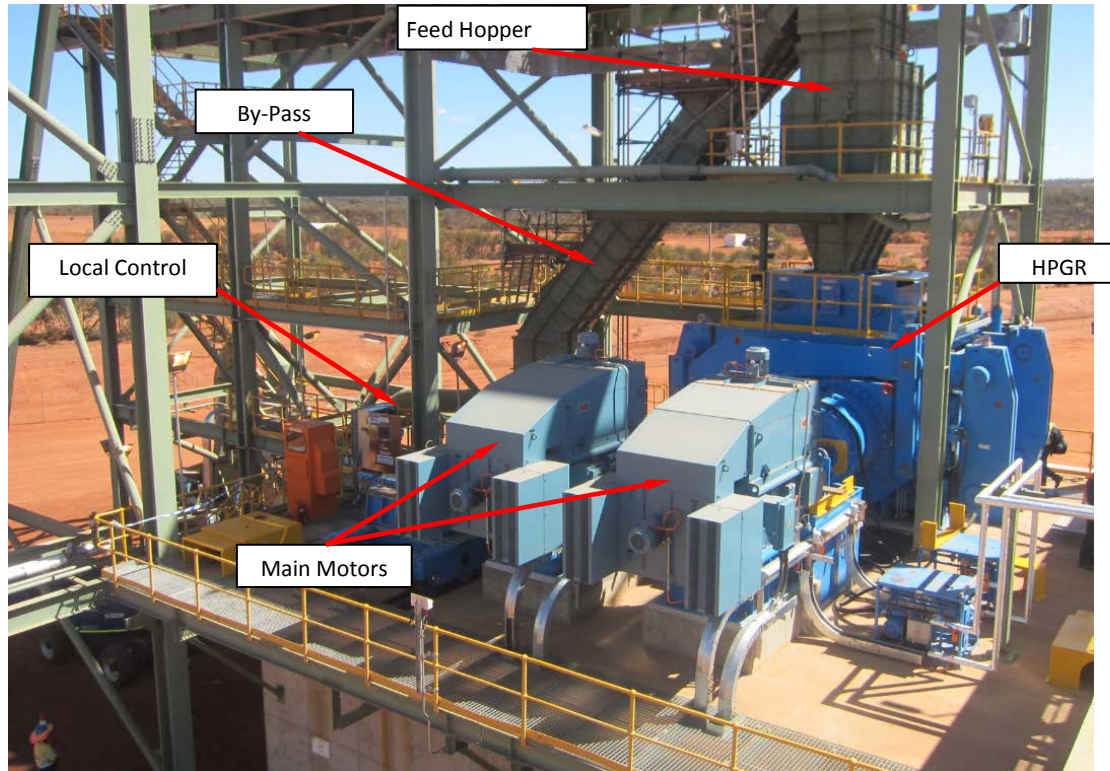


Figure 6 - Main view of HPGR installation at Tropicana (courtesy of Anglo Gold Ashanti)

The HPGR is installed on a concrete platform with the following floor plan:

- On the top deck – HPGR, drive train, gear box cooling and local control panel
- On ground level (below the platform) – hydraulic power pack and lubrication system.

OPERATION CHALLENGES

The plant was designed for treating fresh ore however during commissioning and ramp up oxide ore was the main feed material. This caused significant issues with slumping and build up in chutes which were addressed by adding water where required. During this time the HPGR was operated at a low pressure to ensure adequate gap control with the softer ore.

Roller skew and motor torque control were automated in HPGR control system. Particularly during the operation on soft oxide ore roller skew control was expected to present a major challenge due to expected lack of ore homogeneity - clayey components and uneven moisture distribution in the HPGR total feed (fresh and recycle feed). Once the ore changed to intermediate and later fresh ore operation difficulties were expected to diminish.

During the entire period from October 2013 to February 2015 the original wear linings were in use. In addition to changing ore properties the effects of studded lining wear (development of bath tub profile) at the end of the period added to operational challenges.

Energy consumption and comminution effect

Changing properties of the HPGR feed required adjustment of process specific pressing force in order to achieve desired comminution effect on a consistent basis.

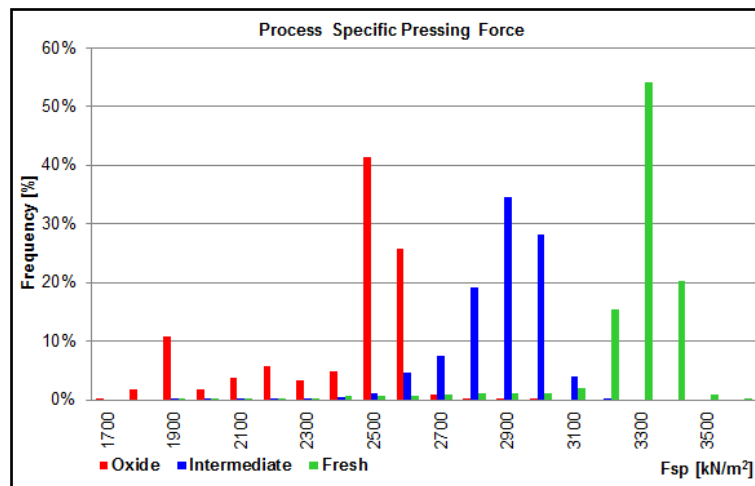


Figure 7 - Process Specific Pressing Force

The histogram presents specific pressing force adjustments that were required to maintain adequate comminution effect while processing oxide, intermediate and fresh ore blends.

The histogram of oxide ore (red) is much wider compared with intermediate and fresh ores. This is the result of fluctuation of ore properties during this period. Increase of ore competency (intermediate and fresh ore) resulted in better stability of selected specific pressing force.

As predicted by the test work during the initial operation on oxide ore, specific energy consumption was considerably lower however it increased once ore competency increased.

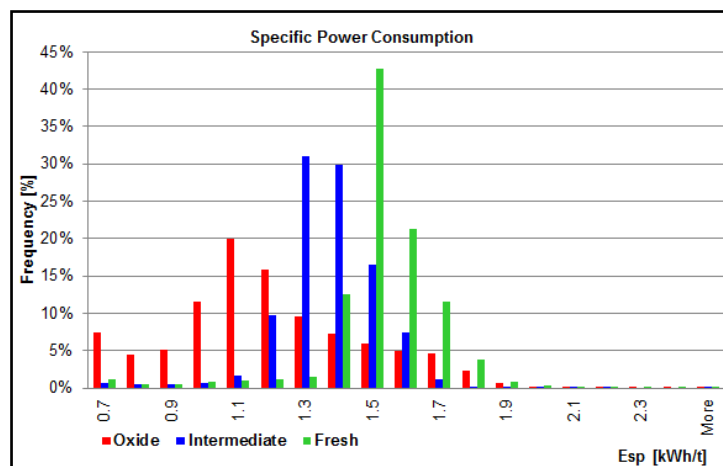


Figure 8 - Changes in specific energy consumption for the oxide, intermediate and fresh ore

Specific power consumption is a function of specific pressing force and ore competency. On average, the following energy input was required:

- Oxide mean 1.14kWh/t Std Dev 0.301
- Intermediate mean 1.32kWh/t Std Dev 0.147
- Fresh mean 1.47kWh/t Std Dev 0.183.

The main aim of specific pressing force adjustments is to achieve desired comminution effect and maintain steady generation of Ball Mill feed.

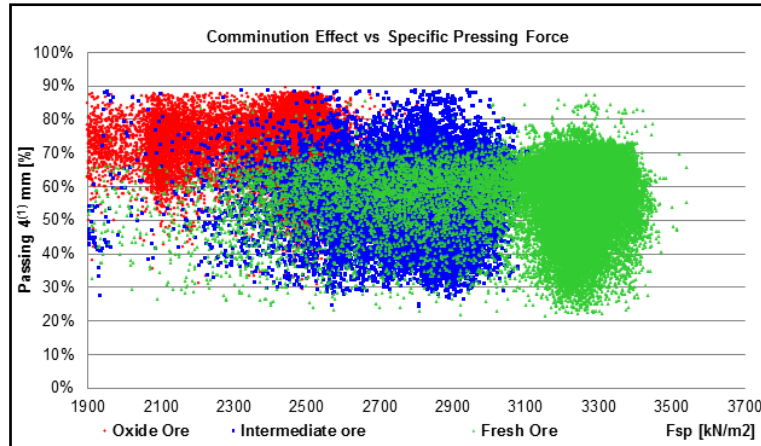


Fig. 9 - Comminution Effect

Please note the data for fresh ore appears to show lower comminution effect. During 2014 (July) the screen aperture was reduced from 4 mm to 3 mm in order to increase processing plant throughput. This change resulted in slightly lower comminution net effect.

The scatter graph presented on Fig 9 demonstrates changes in comminution effect for the three different types of ore. Following mean comminution effect was achieved:

- Oxide mean 72.0% Std Dev 0.074
- Intermediate mean 60.1% Std Dev 0.077
- Fresh (-3mm) mean 57.1% Std Dev 0.088.

The histogram below presents comminution effect for the three analyzed periods of operation.

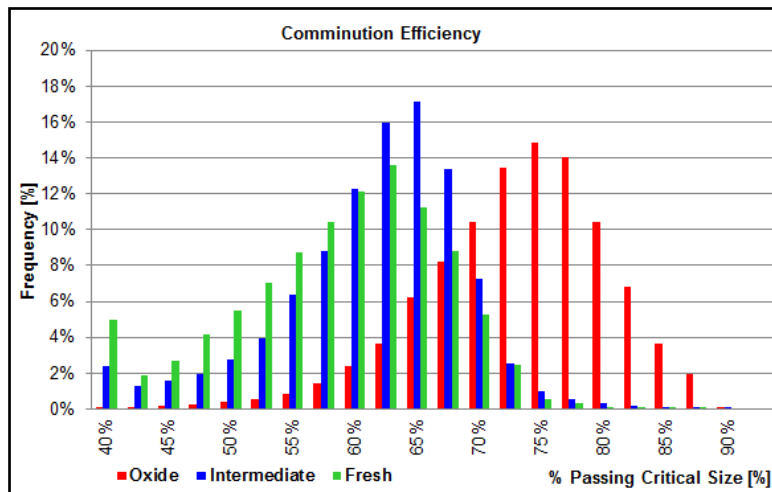


Figure 10 - Comminution Efficiency histogram

As predicted, the best comminution efficiency was achieved when processing weak oxide ore. Specific pressing force adjustments for operation on intermediate ore and later fresh ore resulted in maintaining comminution efficiency better than the design case (42%).

PROCESS CONTROL

Comminution effect and energy consumption presented in the previous section of this presentation demonstrate good control of the process and meeting design requirements. Two parameters that need to be evaluated in more detail are roller skew and main motor torque. These two parameters play a significant role not only in control of process performance of the HPGR but also in achieving low wear rates as well and high operational availability.

- “run-away” roller skew will lead to HPGR trip and loss of production time
- Unbalanced power draw (torque) of main motors may lead to stud breakage and uneven wear of studded lining.

The HPGR control system designed by Köppern automates control of both of these parameters.

Roller Skew control

Roller skew control was perceived as the most important parameter to be controlled. Poor performance of this control loop would have led to HPGR emergency shut downs when roller skew exceeded the threshold.

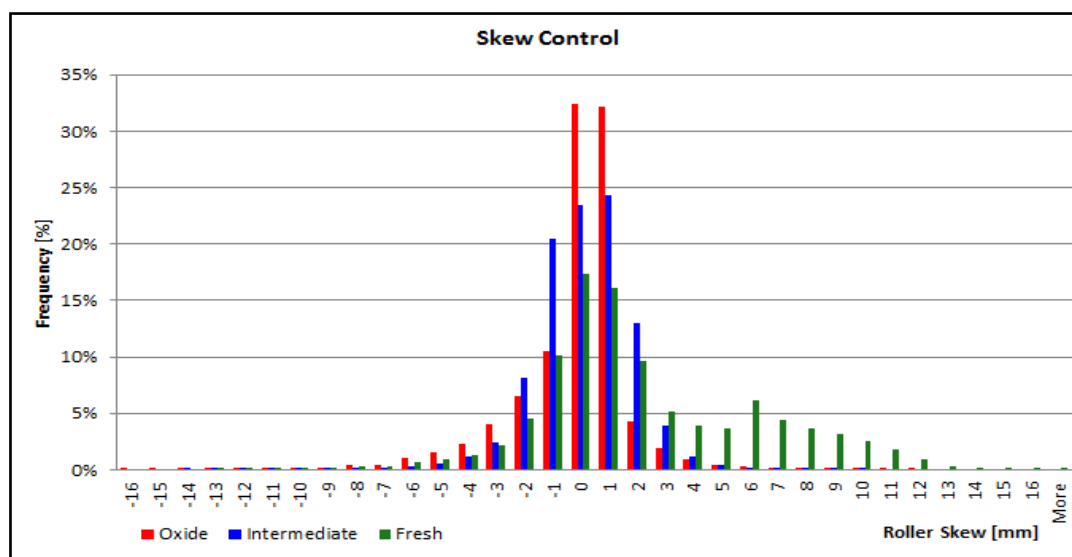


Figure 11 - Skew control during selected operation period

Roller skew presented on Figure 11 is calculated as a difference of roller gap between HPGR drive and non-drive ends.

The control loop performs very well with the occurrence of excessive skew very rare. The graph presented on Figure 11 shows wider distribution of roller skew for the operation on fresh ore. This period of operation corresponds to wear lining after more than 8,000 of on-load hours. At this stage the lining developed a “bath-tub” profile and as such skew control was more challenging.

Motor Torque control

Control of motor torque is also very important, poor balance of motor torque may lead to HPGR trips, uneven wear rates and also stud breakage. Standard torque controls offered by VSD-motor suppliers are not suitable for HPGR application Köppern developed their own control loops for this parameter.

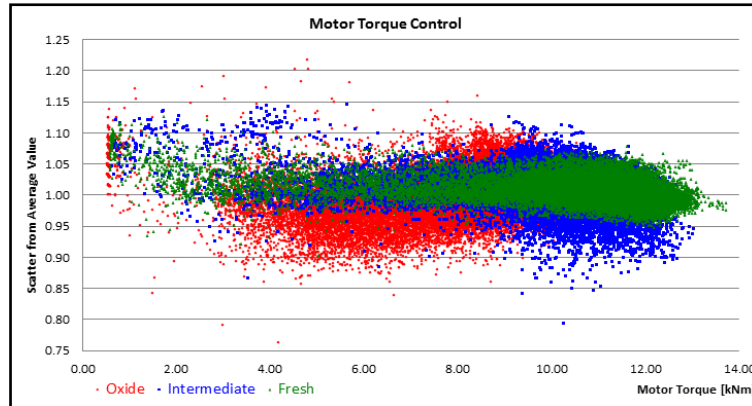


Figure 12 - Motor torque control

The scatter graph presented above shows deviation from average motor torque for each data point, in the event of floating and fixed roller motor torques are the same, the proportion of torques is “1” (flawless control). A difference between the torques is represented by values that are smaller or greater than “1”.

Motor torque control was a challenging exercise during the operation on oxide ore. Lack of process stability and ore homogeneity within the first months of operation were contributing factors to a larger scatter of motor torque.

Once the ore changed to intermediate and later fresh ore the target of motor torque being within +/- 10% of the average was achieved.

Process parameters statistics

Average process key performance indicators were calculated for the analyzed periods of operation on oxide, intermediate and fresh ore types. The results are presented in Table 2.

Table 2 - HPGR process key Performance Indicators

Process Parameter	Unit	Ore Type		
		Oxide	Intermediate	Fresh
Specific Pressing Force	[kN/mm ²]	2,351	2,830	3,209
Specific Energy Consumption	[Kwh/t]	1.14	1.32	1.47
Roller Gap	[mm]	48.29	48.27	47.42
Specific Throughput m-dot	[ts/hm ³]	280	294	282
Fresh Feed	[t/h]	825	975	1032
Recycle Feed	[t/h]	353	629	762
Total Product	[t/h]	1,294	1,540	1,615
Moisture content	[%]	5.90	4.66	2.70
Comminution Efficiency				
% passing 4 mm	[%]	72%	60%	n.a.
% passing 3 mm	[%]	n.a	n.a.	57%
HPGR Utilization	[%]	65%	70%	70%
Analysed Period		6 th Nov	1 st Apr	1 st Jan
		12 th Dec	31 st May	28 th Feb
		2013	2014	2015
	[days]	37	61	59
Number of data-points		34,711	61,707	59,337

The summary statistics confirmed proper operation of the HPGR and expected machine response to changing feed conditions. As the feed material increased its competency the following changes were observed:

- In order to maintain adequate levels of comminution specific pressing force was increased from 2,300 kN/m² to 3,200kN/m²
- The change in specific pressing force resulted in an increase in specific energy consumption of ~33%
- Process specific throughput remained steady for all three types of ore.
- Change of ore type from oxide to fresh resulted in a substantial reduction of HPGR feed stream moisture.
- Operating roller gap is steady for all three ore types indicating good process control
- Deterioration of comminution efficiency was expected when process progressed to harder ore. However even for intermediate and fresh ore types the comminution efficiency was excellent and this allowed TGM to reduce HPGR screens aperture thus reduce Ball Mill feed top size.

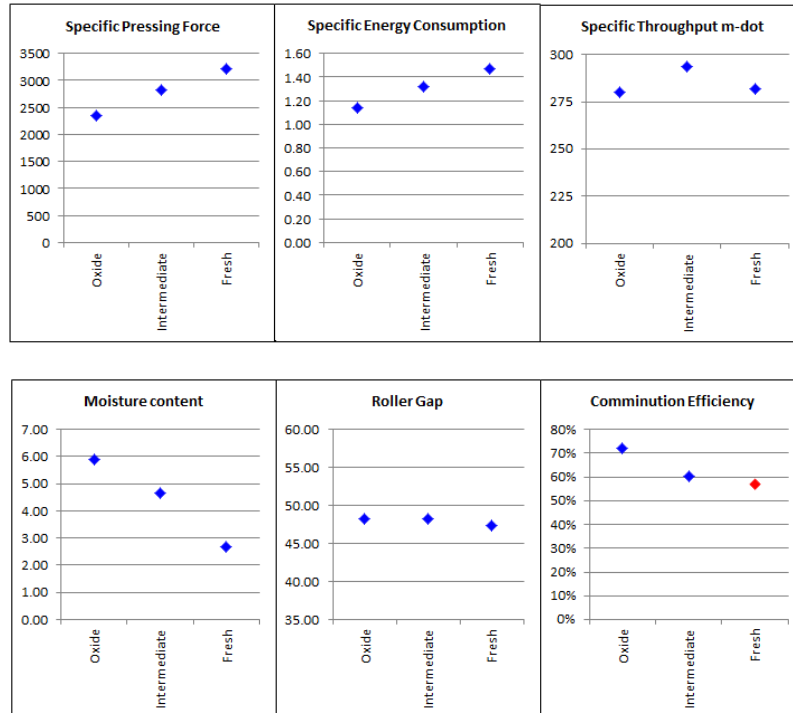


Figure 13 - HPGR process KPI's

Please note comminution efficiency for fresh feed (red data point) is based on cumulative % passing 3 mm. Oxide and intermediate ore types (blue data points) refer to 4mm screen aperture

The analyzed three periods of operation confirm the satisfactory performance of the supplied HPGR and excellent process control by Tropicana Gold Mine personnel.

WEAR PERFORMANCE OF STUDED LINING

Wear performance of the studded lining at Tropicana Gold Mine application was the most discussed issue during project design. Wear tests were performed and provided adequate information to estimate expected lining service life. Based on Köppern calculations expected wear life was 8,000 on load hours. The wear warranty agreed for the contract was settled at 6,000 on load hours.

Based on previous experience the most challenging period for wear rates are the first months after commissioning. During this period Koeppern expected high frequency of operation on insufficient feed rate as well as frequent plant stops. In addition lack of experience of operators could have added to wear issues.

Activation of the HPGR automatic control loops was the highest priority as it could assist in elimination of human errors.

On the following pages we present wear results for the entire period from commissioning in October 2013 until January 2015 when the last wear measurement was conducted.

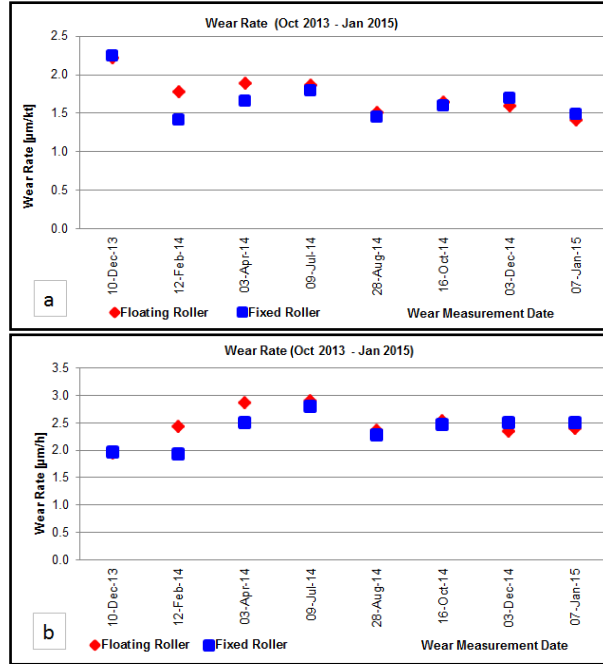


Figure 14 - Stud lining wear rate for period from commissioning in October 2013 - January 2015
 (a)Wear rate in microns per '000t of total HPGR throughput (b)Wear rate in microns per on load hour

As expected the wear rate ($\mu\text{m}/\text{kt}$) of operation was much higher compared with the rest of the period. Once the process stabilized the wear rate settled at ~1.6 to 1.7 $\mu\text{m}/\text{kt}$.

The wear rate measured in $\mu\text{m}/\text{h}$ beginning of September 2014 the wear lining reached the warranted 6,000 operation hours. The condition of the lining continued to be very good and in February 2015 the original lining was still in service after more than 8,000 on-load hours.



Figure 15 - Wear lining condition ~1,000 hrs in service (courtesy of AngloGold Ashanti)

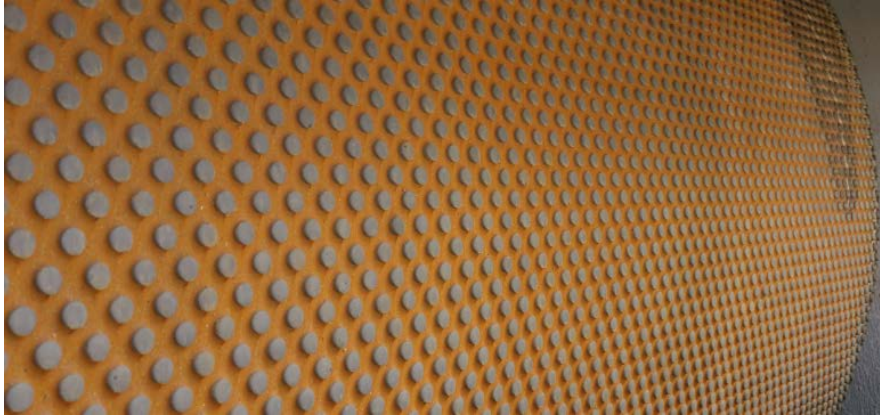


Figure 16 - Wear lining condition ~8,500 hrs in service (courtesy of AngloGold Ashanti)

Figure 15 shows wear lining with autogenous protection layer (APL) present. Please note very uniform and compact APL and even wear of studs. Figure 16 presents lining after autogenous protection layer was removed, stud protrusion is uniform – 5 to 6 mm.

Stud breakage

To date stud breakage has been very minimal. At the beginning of the operation (first 2-3 months) some edge protection carbides were chipped and subsequently replaced (~ 15 plates). The cracks in the edge protection carbides were due to collision with cheek plate edge. Once adjusted the breakage of edge plates did not re-occur.

Breakage of center studs was also very minimal with an odd stud chipping or breaking occasionally. During the 11,000 (May 2015) hrs of operation less than 30 studs broke or chipped (please note the entire lining is composed of some 38,000 carbides). Some of the studs were replaced during planned plant shut downs.

During the 11,000 hrs of the lining life in no case did the process have to be shut down due to stud breakage or the need for urgent lining repair. The maintenance of the studded lining did not have any negative effect on HPGR mechanical and process availability.



Figure 17 - Examples of broken, chipped center studs and studs removed from wear lining during maintenance (courtesy of Anglo Gold Ashanti).

As expected the wear lining developed a so called “bath-tub” profile. Towards the end of wear lining life the ‘bath-tub’ profile made process control more challenging but not impossible.

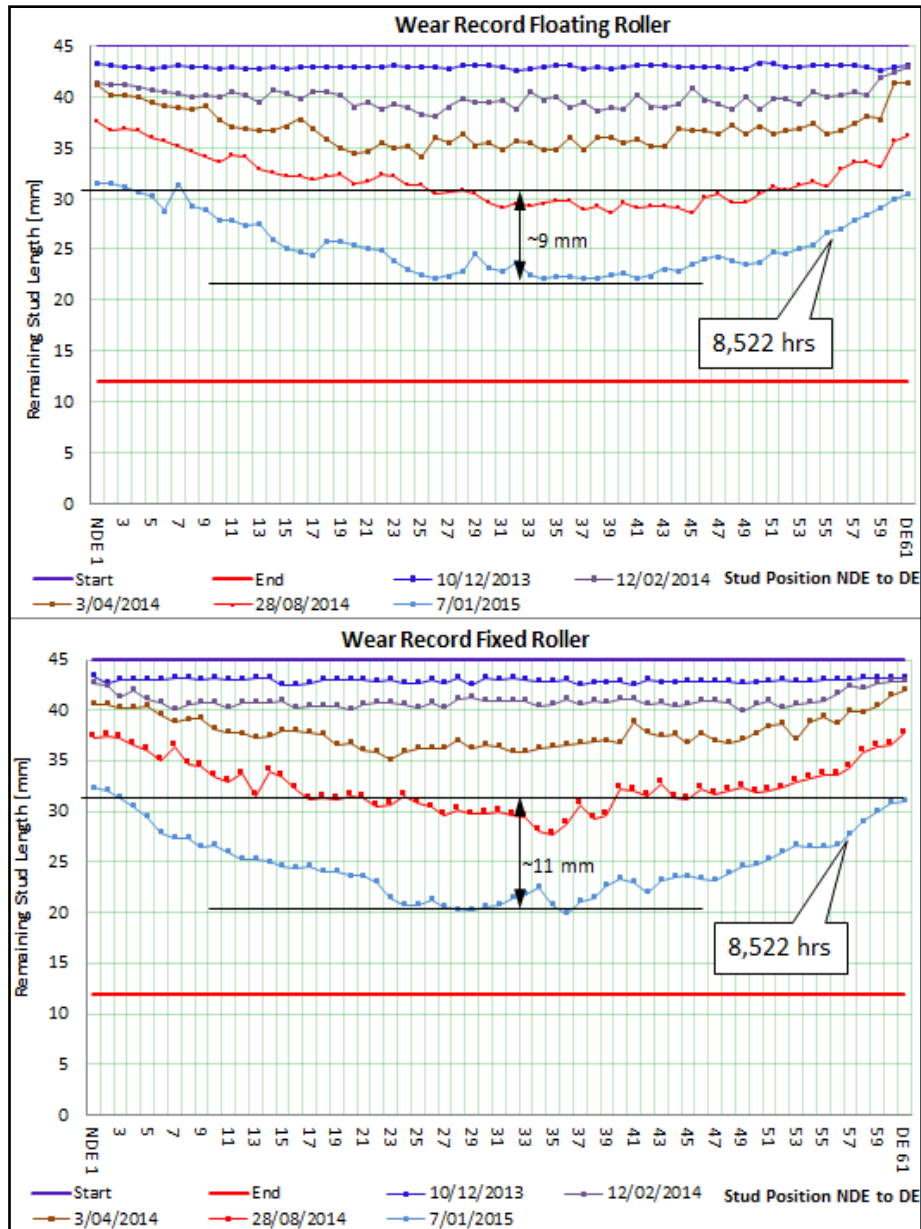


Figure. 18 - Wear profile progression from start to 8,500 on load hours

PROCESS IMPROVEMENTS

During commissioning it became evident that the fresh feed to the HPGR would run out quite regularly. Originally the intent was to stockpile the recycle material rather than operating the HPGR on this high moisture material. Due to the high frequency of fresh feed not being available this original concept was not practical. To ensure high and consistent feed material for the ball mill it was required to keep operating the HPGR during times where no fresh feed was available and run the process on recycle feed only. The higher moisture content in the recycle feed washes out the autogenous layer which has the potential to increase the wear of the rollers. AngloGold Ashanti considered this to be an acceptable risk due to the on-off operation of recycle material which allowed the autogenous layer to quickly form again. As a contingency measure weekly wear lining inspections were introduced to assess for signs of increased

wear and stud protrusion (which would increase stud breakage). The availability of fresh feed material has improved since but it is still part of plant control philosophy to run on recycle feed only when required. Bearing in mind longer than predicted roller life it is regarded as an acceptable risk.

The grinding circuit was designed with a metal detector on the HPGR feed belt and on the recycle feed product belt with diversion gates on the head chutes. This allows the system to bypass the HPGR when metal is detected on the feed belt and to stockpile recycle feed rather than sending it back to the HPGR when metal is detected on the recycle product belt. The installed fines stockpile screen could not produce sufficient fines material required to ensure consistent feed to the mill during downstream stoppages and maintenance. As a result HPGR recycle material was also stockpiled (oversize stockpile) and fed back into the circuit via the fines reclaim circuit to ensure continuity of production. This however eliminated the only means of removing the metal out of the circuit. Changes were made to the fines stockpile screen to increase the production rate of the fines stockpile however when required the oversize material will still be stockpiled and fed back into the system. As a result of this control philosophy an additional belt magnet to remove metal from this circuit is being considered.

During Tropicana project design stage a safety factor was applied to the expected comminution effect – 43.4% instead of 57% passing 4 mm (as predicted by KMA). This resulted in additional capacity being available in the HPGR. To utilize this additional capacity the HPGR wet screen panel apertures were changed to reduce the feed size to the ball mill from 4mm to 3mm. This change facilitated increased ball mill throughput and reliability.

MAINTENANCE

The feed chute level is controlled via a radar level sensor which controls the HPGR variable speed feed belt. When this sensor gets dirty it gives a false reading and this may lead to loss of choke feed conditions and “empty hopper operation”. This contributed to the wear issues in the chute and feed chamber. The level sensor was moved and compressed air was added to assist with keeping the sensor face clean.

During the first months of operation TGM experienced extensive wear in the feed chute and feed chamber to the extent where the HPGR circuit had to be shut down for emergency repairs in between the six weekly shutdowns. Improvements were made by replacing the plastic lining with a combination of ceramic tiles and 600 Brinell hardness plates. Rubber lifter bars were also installed in the feed chute to assist with protecting the wear plates and extending service life.

Problems are still being experienced and alternative instruments for level control are being considered.

Corrosion on site is a major issue. The plant water used for wash-downs is highly saline and as with other equipment corrosion also affects the HPGR. Proper lubrication and corrosion protection measures are an ongoing challenge.

During the first 17 months of the HPGR operation maintenance of the HPGR did not produce any major challenges. The majority of the maintenance and repairs were carried out during planned shut downs and HPGR unplanned trips were kept to a minimum.

Major maintenance repair challenges to date:

- Bearing seal failure – repaired during planned shut down
- Failure of roller retraction system – repaired during planned plant shut down (this issue resulted in minor HPGR downtime during first months of operation).
- Gear box water cooling blockage – repaired during planned shut down
- Hydraulic leak at one of main cylinders - repair commenced during planned shutdown but was completed approximately six hours late due to unexpected corrosion of the hinge

- Hinged frame pin corrosion – lack of regular lubrication of the hinged joints led to pin seizing and tremendous difficulty with frame opening. The problem is un-resolved at the time of writing this paper.
- One of the transformers of the HPGR drive train failed. This breakdown led to an unplanned shut down of the processing plant. It was not linked directly to the HPGR but was part of the Köppern HPGR equipment supply. The transformer was repaired by the OEM and Tropicana Gold Mine personnel.
- HPGR mechanical availability during the first 17 months of operation is better than the 95%

PROJECT SUMMARY

In summary, incorporation of Köppern HPGR in Tropicana Gold Mine flow sheet is regarded as being very successful:

- The HPGR was manufactured and supplied within the contracted time frame
- Delivery of the equipment to Australia was on time
- Installation and commissioning was on time and with no cost over-runs
- Since start-up in October 2013 until the end of February 2015 the HPGR produced:
 - ~ 7Mt of Ball Mill feed
 - ~12Mt of total HPGR product (HPGR discharge)
- Wear lining cost per tonne cannot be provided yet as the lining is still in operation. These costs are expected to be less than \$0.25 per tonne of Ball Mill feed
- HPGR mechanical availability during the first 17 months of operation is better than the 95%
- Process performance was as predicted
 - Comminution effect is as predicted by KMA after test work completion
 - This allowed for change of screen aperture and increase of Ball Mill throughput
- Specific power consumption is slightly lower than predicted. This produces a reserve in power available for possible tough ore that may be mined in future.

FINAL COMMENTS

The success of HPGR operation at Tropicana Gold Mine has produced invaluable data. The experience gained during the first year of operation clearly shows that if effective communication between the Miner, Engineering Company and OEM can be achieved, as it was the case for the Tropicana Project, then HPGR technology can be successfully applied to processing of hard ores.

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