Stable mill operation and maximised production

CASE: Nkomati Nickel Mine, South Africa
Advanced process control on a modern, high capacity concentrator grinding circuit helps increase production by 4.3% and decrease energy consumption by 6.7%.
The ECS/ProcessExpert® optimisation system has enhanced competitiveness at the Nkomati mine. Stabilised performance, optimised production and reduced overgrinding are just some of the benefits. The success of the system is further demonstrated by a 96% utilisation factor.

Background
The Nkomati Nickel Mine in South Africa processes one of the world’s hardest ores in a 375k tpm autogenous grinding circuit. The plant employs an unconventional processing circuit, comprising a primary autogenous (AG) mill and pebble crushing circuit followed by a secondary hybrid pebble/ball mill and classification cyclone cluster.

The circuit is designed to process 4.5million metric tonnes per annum of Nickel, Copper, Cobalt and Platinum group metals ore at a feed rate of approximately 575 tph. The circuit operates 24 hours a day, 363 days a year, at an availability of 90%, achieving a process rate of 375,000 tpm.

Objective
To stabilise operation, improve process performance and facilitate ramping up to full production, Nkomati decided to install an FLSmidth advanced process control system.

Grinding is an important contributor to operating costs of mineral processing facilities and Nkomati wanted to operate its grinding circuits as close as possible to the best operating point, minimising energy consumption. By improving process control, Nkomati also hoped to reduce overgrinding and therefore grinding cost and flotation losses.

Defining the project
FLSmidth had supplied the grinding mills and pebble crushers at Nkomati and was also selected to supply an ECS/ProcessExpert system, an advanced process control solution to stabilise and then optimise key plant processes.

As part of the control strategy definition, Nkomati and FLSmidth worked together to identify the key process measurements required for control. It was decided to split the application into two main modules: the primary grinding circuit comprising the AG mill and pebble crushers, and the secondary grinding circuit comprising the ball mill, sump and cyclones.

The objectives were to:
- Stabilise AG mill operation and prevent over filling of the AG mill
- Minimise circuit stoppages and allow controlled operation at maximum and significantly reduced feed rates
- Optimise control and balance loads between the AG and ball mills
- Avoid sump spillage and maintain cyclone inlet pressure to set points
- Maintain constant flow to the flotation plant
- Keep particle size analysis (manual value) on target
- Improve grind and energy efficiency

Nkomati selected FLSmidth to supply an advanced process control solution to stabilise and optimise key plant processes.
The eight-step methodology includes the following activities:
1. Project planning
2. Kick-off and process interviews
3. Application design
4. Primary commissioning
5. ECS/ProcessExpert system training
6. Remote monitoring and tuning
7. Follow-up visit
8. Long-term support

Results
A series of tests compared performance data with the ECS/ProcessExpert system on and off. As identical conditions for each test were extremely unlikely due to the variations in ore characteristics, eight tests were carried out, providing enough data to account for potential operational disruptions that commonly occur in grinding circuits.

The eight tests, each lasting 24 hours, took place over eight days. Each day, the ECS/ProcessExpert system was alternately switched on and then the next day off. The sequence alternated for 8 days, 1 day with the ECS/ProcessExpert system being used and 1 day with the system off.

The results demonstrated that using the ECS/ProcessExpert system improved performance of the Nkomati grinding circuit.

Solution
FLSmith specifically tailored the ECS/ProcessExpert system to the needs of the Nkomati plant.

The system was designed to manage all variables and parameters typical in AG mill operation with the objectives of maintaining stable mill operation and material flows, while maximising production and optimising product particle size.

FLSmith conducted process interviews to help design the control strategy. These interviews were followed by process observation and analysis, which provided additional evidence to confirm and suggest modifications to the initial control strategy. The system was prepared based on these agreed upon control strategies.

On installation, it was straightforward to establish communication with the main process control system due to the compatible drivers in the ECS/ProcessExpert system. The ECS/ProcessExpert system required no third-party systems to be installed and the native I/O drivers were used to communicate directly with the Programmable Logic Controllers. Within 5 days of installation, all the signals and tags had been checked and the system was left gathering data and under remote monitoring for a period of 12 weeks.

Through daily meetings between FLSmith and Nkomati, the system performance was analysed, areas of opportunity identified and the required activities towards completion of the project were agreed between both parties.

FLSmith completed commissioning of the ECS/ProcessExpert system with a performance test in 2011.

User-friendly interface
The user interface was designed to display the controller mode, control status, online measurements, actuators, main mimic and trend display. It also identifies and displays the actions being performed by the application and allows the operators at Nkomati to partially enable/disable the control strategy whenever an instrumentation or process problem occurs. Information regarding the utilisation of the system, one of the project’s success criteria, is also presented to operators.

Critical for success
The success of the ECS/ProcessExpert system at Nkomati depends on FLSmith’s eight-step methodology, which comprises all the activities required for the efficient development of this advanced process control solution. FLSmith aligned Nkomati’s expectations with the application goals for the successful commissioning of the system.

The system is designed to maintain stable mill operation, maximise production and optimise product particle size.

Using the ECS/ProcessExpert system, compared to not using it, resulted in:
- 4.3% increase in production
- 6.70% decrease in the whole circuit energy consumption
- 45% process variability reduction in AG mill weight
- 44% process variability reduction in cyclopack pressure
- 28% process variability reduction in pump speed
- 34% quality variability reduction in P80
- 24% quality variability reduction in cyclone overflow % passing 75μm
When Nkomati used the advanced process control system the mine gained operational and economic benefits during circuit operation, and production performance and circuit stability were significantly better than during manual control.

On average, production was 4.3% higher and the whole grinding circuit energy consumption was 6.7% lower when the ECS/ProcessExpert system was used. By independently analysing each of the main machines, it was found that the energy consumption of the AG mill, cyclone pump and ball mill were 5.10%, 6.48% and 9.25% respectively lower when the ECS/ProcessExpert system was controlling the grinding circuit.

The production results clearly indicate that the performance of the grinding circuit in both operational and economic terms was highly improved when the ECS/ProcessExpert system was utilised.

In terms of process stability, on average, the process variability of the AG mill weight level, ball mill weight level, cyclone pack pressure, pump speed and density was respectively 36%, 43%, 44%, 28% and 15% lower when the ECS/ProcessExpert system was used.

The process stability results clearly indicate that the mill stability was significantly improved when Nkomati used advanced process control. Improvement in consistency and stability of grinding circuit control is expected to yield benefits in terms of ultimate circuit capacity and overall circuit power efficiency. The reduction in pump speed variation resulted in an increase in pump power efficiency, which coupled with the expected concomitant wet end wear reduction is expected to translate to significant financial benefit.

The improvement in the stability of the grinding circuit in terms of product quality translates directly to improved stability in the flotation circuit, which proved to result in some improvement in the recovery of metals.

**Quick return on investment**

Nkomati experienced a fast return on its initial investment through increased production and reduced energy consumption. The payback time was less than 2 months, making this a very successful project in both operational and economical terms.

The Nkomati ECS/ProcessExpert system has proved itself to be extremely reliable and no additional tuning has been necessary since it was handed over to the plant. On average, the utilisation factor is 96%.

Danie Smit, concentrator manager at Nkomati says, “I am very excited about the full potential of the ECS/ProcessExpert system. We are certainly seeing the benefits of using the system and I am confident it will greatly contribute to achieving our business plans. This project has been a success and it was the right decision.”

After this implementation of the ECS/ProcessExpert system, Nkomati is considering other incremental automation applications, which can take advantage of the existing infrastructure, reducing implementation costs and further decreasing the payback period.

**Quick return on investment**

Using advanced process control resulted in significantly improved production performance and circuit stability compared to manual control.

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The following variables were recorded to evaluate the performance of the ECS/ProcessExpert system:

**Production data**
- Circuit throughput (new feed) in dry metric tonnes per hour
- Circuit power consumption in kWh/t
- Primary mill power consumption in kWh/t
- Average cyclone feed pump power consumption
- Secondary mill power consumption in kWh/t
- Pebble crusher power consumption in kWh/t

**Stability data**
- Primary mill mass using bearing back-pressure monitoring
- Secondary mill mass using bearing back-pressure monitoring
- Density
- Pump speed variation

**Quality data**
- Cyclone inlet pressure in PSI or kPa
- Particle size (P80) in cyclone overflow in μm read every 2 hours
- Cyclone overflow % passing 75 μm

Using advanced process control resulted in significantly improved production performance and circuit stability compared to manual control.