

Case Study: Mogale Gold

South African Systems Integrator Opto Controls Designs Control System for Mine Tailings Reprocessing

Background

Mine tailings are the crushed and milled rock residue that remains after mineral extraction. These tailings must be deposited for storage in a cost effective way that also meets environmental guidelines and mandates. Dams, dumps, and other types of surface piling are some of the more common tailings deposition methods used today. However, these all pose serious environmental concerns, as tailings often contain trace and sometimes substantial quantities of the metals found in the host ore, as well as certain amounts of chemicals and compounds used in the mining processes. As a result, establishing and maintaining tailings dumps represent a significant cost for mining companies.

A New Strategy: Tailing Reprocessing

Historically, mineral separation processes have been somewhat inefficient because after the required crushing, grinding and metallurgical treatment, some amount of valuable metal is left behind in the residue. But recently, improved mining technologies and the ever-increasing price of gold in the marketplace have opened the opportunity for mining companies to purchase old mining dumps and metallurgically treat the tailings in order to recover residual gold.

South African miner Mintails Limited is currently focused on exploring, evaluating, and processing hundreds of millions of tons of surface gold-bearing tailings in the Witwatersrand ("Rand")

area of South Africa—a region that, according to many experts, has produced more than 40% of all the gold ever mined from our planet. These types of gold reclamation efforts are never 100% efficient, and automation and control plays a significant role in improving the metallurgical processes. With the help of systems integrator Opto Controls, each month Mintails is collecting significant amounts of the valuable metal. In the process, the company is positively impacting the environment by clearing away mountainous, land consuming, and unsightly dumps.

Opto Controls

Opto Controls (Pty) Ltd has been a supplier and integrator of hardware and software for industrial automation, remote monitoring, and data acquisition applications for more than 10 years. Specializing in solutions utilizing Opto 22 components and systems, Opto Controls' broad project and industry expertise includes access control and security, print production monitoring, and factory automation. Company president Mike Harrison and Process Control and Programmer Engineer Adam Carless head a team contracted by Mintails to assemble and configure an automation system for Mintails' Mogale Sands Plant ("Mogale Gold.") This system connects to, monitors, controls and acquires data from a large assortment of field devices, equipment, and instrumentation and also manages the many mechanical and chemical processes used to remove the gold from the tailings.



Mine tailing dumps extend far across the landscape.

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The Opto Controls system's key components are Opto 22 rack-mounted and standalone programmable automation controllers (PACs) and I/O housed in containers located at various areas of a processing plant situated between the gold mine and the dump.

"Initially, these controllers were to be networked via fiber optic cable, but Mintails management later decided to go with a wireless solution from MikroTik so as to avoid having to dig trenches and lay conduit for the cabling," explains Harrison.

The MikroTik platform features a Linux-based operating system, omnidirectional antennas, and wireless communication capabilities utilizing all four of the 802.11 standards (a/b/g/n), as well as frequency ranges within the industrial, scientific and medical (ISM) radio bands. The system also has meshing capabilities, data transfer speed of up to 350 Mbps, and a range that easily bridges the average distance (about 150 meters) between the Mogale site controllers.

Tailings Processing

Tailings processing begins with the pumping of water from the mine to the dump site, where it's used to wash down the tailings and create slurry.

The Opto Controls system regulates the pumping of approximately 600 cubic meters of water per hour. The controller communicates to digital output modules—used to start and stop the water pumps and also to change the state of valve actuators within the pipeline—along with

digital input modules that aggregate feedback from flow and level switches and differential pressure sensors that confirm that pumping is executing properly.

"We're also connecting to magnetic flowmeters to detect and monitor flow rates, and analog input modules to get feedback from scores and scores of valves," says Harrison. "These flowmeters have no moving parts [making them low maintenance and ideal for use in pumping dirty liquids] and we wire these to the I/O."

Many of these I/O modules are 8-, 16-, and 32-channel high density modules that provide significant savings in both cost and rack space. In some cases, however, Harrison purposely chose to use Opto 22's older G4 family of I/O, which have higher current ratings per module (upwards of 3 amps) and often prove a better choice for driving heavy duty motors and pumps like the ones used at Mogale Gold.

When the water arrives at the dump, large water jets disperse the water and the resulting slurry gets pumped back to the mine. The slurry then goes through a series of screens for removal of debris and other material.

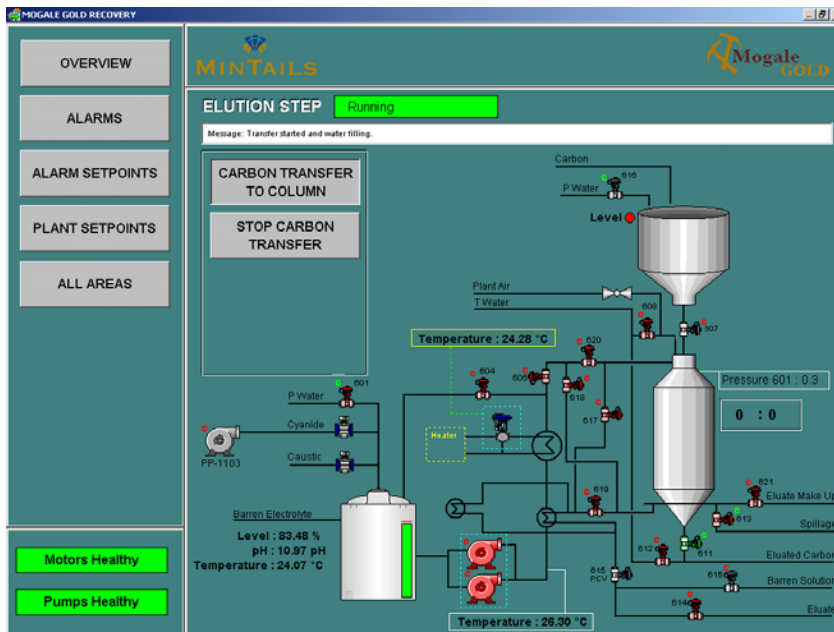
Carbon-in-Leach (CIL) & Elution

Leaching, sometimes referred to as metallurgical extraction, is a chemical process for removing minerals by dissolving the mineral and moving it from a solid to liquid state. The dissolved gold is then converted to a more concentrated solid state. This is accomplished by absorbing the dissolved gold onto activated carbon. This form of carbon is extremely porous (a single gram can have the same surface area as a small parking lot), making it well suited for adsorbing gold.

During elution, gold is stripped off the carbon by a hot chemical mix of caustic and cyanide. At an operator's command, the Opto Controls system opens the necessary valves, starts a series of feed pumps, and begins transferring water, caustic (sodium hydroxide), and sodium cyanide into the elution make-up tank. A large diesel burner is started and the cyanide solution is circulated through heat exchangers to bring the solution to a temperature of 80-90 °C, after which, the solution is fed into the column and the elution make-up tank. The Opto Controls system plays a major part in all of these processes.



Large pumps bring water to the dump site to create slurry.



HMI screen detailing the elution phase of tailing reprocessing.

“There are several devices and many types of instrumentation used in this process and our system connects to and monitors and/or controls nearly all of them: motors on the caustic and cyanide feed pumps, pressure indicators, temperature probes on storage tanks, air valves, and flow meters, just to name a few,” explains Harrison.

Of particular importance are the variable speed drives (VSDs) that regulate the pump motors. To ensure that this equipment operates optimally and that proper flow rates are maintained, Carless has created several proportional integral derivative (PID) loops.

PID Control

With PID loop control, the difference between a process variable and the desired setpoint is measured, and the controller attempts to minimize any disparity by adjusting the process control outputs. In operations at Mogale Gold, the differences between the desired flow rates and the actual flow rates are measured, and the disparities are corrected by the controllers that communicate with analog output

modules used to constantly adjust the speed of VSDs that regulate the pumps.

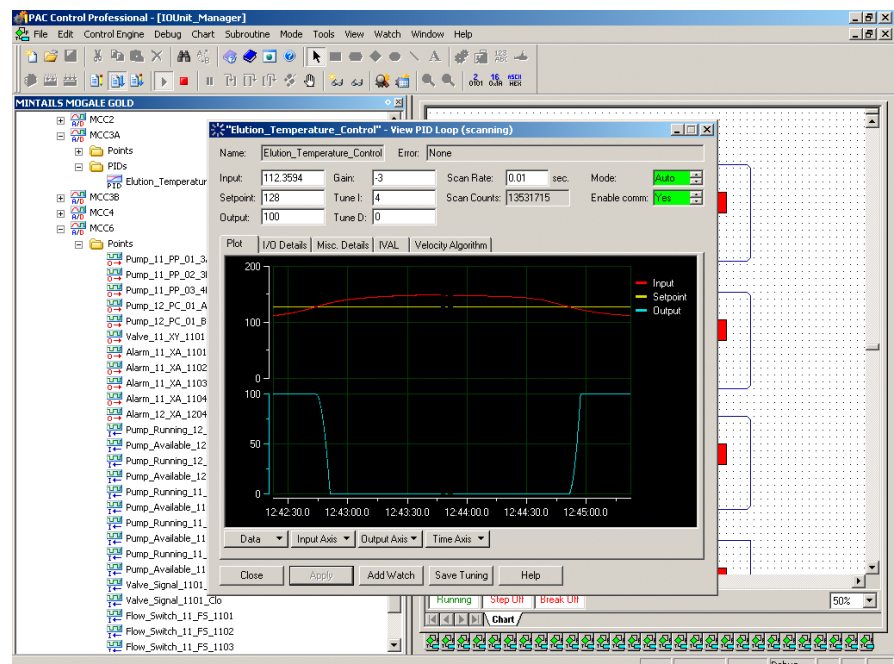
A Distributed Architecture

Significantly, these PID loop control calculations are not performed by the Opto 22 controllers, but by remote processors local to the many racks of I/O scattered across the Mogale site. PID calculations are ongoing and processing-intensive, and offloading these functions from the controller to the I/O created a distributed architecture that provides many benefits. Chief among these is a significant reduction in chances of a system-wide failure, because if the host PAC should malfunction, the independent I/O processors would continue to perform without interruption.

“For Mogale, this means that if one of the central controllers should somehow get knocked off line,

all PID-dependent flow would continue to take place, and potential catastrophes like slurry overflow would be avoided,” explains Carless.

PID control also plays a role in Mogale’s cyanide-related processes.



Process Control Engineer Adam Carless handles PID programming for regulating temperature and flow related processes at Mogale Gold.

Cyanide

During the carbon-in-leach and elution processes, it's critical to avoid the conversion and release of hydrogen cyanide liquid as cyanide gas, which is extremely poisonous. The cyanide may begin to convert to its gaseous state through the acquisition of free protons. Therefore, during Mogale's gold processing, the free proton concentration of the cyanide is kept low through the addition of an alkali such as quicklime (calcium oxide) to ensure that the pH level is maintained above 10.5.

"The cyanide is so dangerous we had to design parts of this particular process to be completely automated with no operator override," says Carless.

Cyanide analyzers and pH sensors interfacing to analog input modules provide continuous readings, and PID loop control is used to perform the calculations needed for chemical dosers to add the appropriate amount of lime. As a safeguard, if the pH reading is less than 10, the cyanide will not be added and the elution process is automatically suspended until the problem is rectified.

The Opto Controls system also controls burners and monitors temperatures as the caustic/cyanide solution is heated, along with the pumps that bring the carbon and slurry from CIL to a measuring hopper. A level probe communicates through an analog input module to the controller and carbon transfer is automatically ceased when the hopper is full.

The carbon is then ready to move from the hopper to elution. This step is initiated (and stopped) manually, but Harrison says that eventually the goal is to have this process (and most others that rely on an operator) fully automated.

During elution, the caustic/cyanide solution strips the gold, making it easy to extract. The solution is electrolyzed¹, resulting in separation of the gold, which is then plated onto cathodes. The solution is then tested to determine the volume of caustic and cyanide required for the following batch. Air is used to purge the elution column of solution and the residual liquid transferred back to the elution tank. The solid carbon is then transferred to a measuring hopper via transport water. With the elution column drained, it is now ready for the next batch.

Alarming & HMI

The slurry process takes from 18 to 20 hours and the total elution process approximately twenty. Full recovery and smelting averages about two days from tailings to gold, so smooth execution of each

1. Electrolysis uses electricity to drive a chemical reaction. An electric current is passed through an ionic substance that is either molten or dissolved in a solvent, resulting in chemical reactions that cause the separation of materials.

phase is extremely important. To help ensure this, Opto Controls has included numerous alarms in the control programs they've designed. For example, the established flow rates for the water, slurry, and chemicals used during various stages of the process are carefully monitored, and operators receive visual alarms on human-machine interfaces (HMIs) viewable on PCs and operator interface terminals located throughout the site. Upon receiving these types of alarms, the operators can then adjust pumps, valves, and other devices and instrumentation appropriately.

"We also have alarms established for when pH levels drop too low and some relating to the pressure readings we're getting," says Carless. "Equipment failures and safety spray stations are also alarmed. As we programmed with PAC Control [control programming software] we used many conditional statements to define the functionality and 'next steps' of the controllers whenever alarms are triggered."



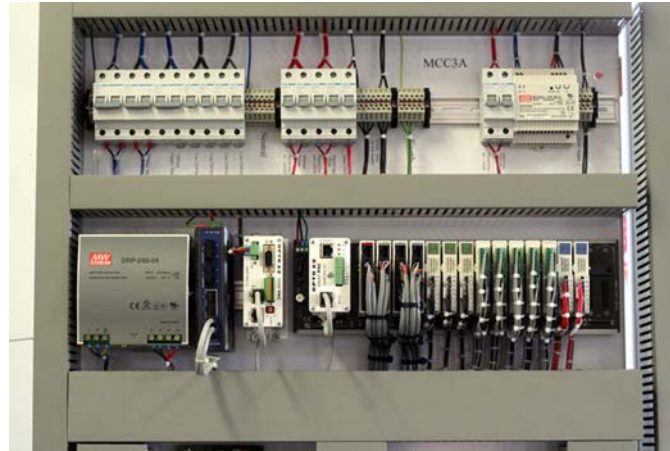
The Opto Controls control systems are located in large containers like this one in front of the large storage tanks.

The HMI development tool is PAC Display, companion software for PAC Control. Mintails management had considered Invensys' Wonderware, one of most widely deployed HMI packages used in mining and many other process industries. However, Wonderware's licensing cost per seat proved to be very expensive. Fortunately, it was determined that the PAC Display HMI package would provide all of the necessary functionality, at a far cheaper cost.

Ultimately, Mintails' gold recovery activities on the Rand will process some 322 million tons of surface tailings. As stated in the company's annual report, Mogale Sands Plant (Mogale Gold 1) production for the 2009 financial year was 1.7 million tonnes, producing 571 kg (18,365 oz) of gold.

Environmental Benefits

Historically, throughout South Africa and the Rand in particular, mining has had an adverse effect on the environment. In this regard, the Mogale project has the added benefit of correcting or offsetting this type of negative impact. The gold dumps at Mogale, in addition to being unsightly, are a source of dust and water pollution. These dumps could also potentially be leaking contaminants into the groundwater and/or affecting the quality of surface water resources.¹ Mintails' removal of these dumps will decrease the dust as well as both surface and groundwater pollution. Also, by clearing the land, Mintails is effectively providing valuable new real estate for development all over the West Rand.



Opto 22's line of standalone and rack-mounted SNAP PACs are the key components of Opto Controls' automation systems.

About Opto 22

Opto 22 develops and manufactures hardware and software for applications involving industrial automation and control, remote monitoring, and data acquisition. Opto 22 products use standard, commercially available networking and computer technologies, and have an established reputation worldwide for ease-of-use, innovation, quality, and reliability. Opto 22 products are used by automation end-users, OEMs, and information technology and operations personnel. The company was founded in 1974 and is privately held in Temecula, California, USA. Opto 22 products are available through a worldwide network of distributors and system integrators. For more information, contact Opto 22 headquarters at +1-951-695-3000 or visit www.opto22.com.

Future Plans: Mogale Gold 2

Construction of a second gold processing plant adjacent to the existing one is nearly complete and this facility recently produced its first gold bar. Once the plant is fully operational, it's estimated that Mogale Gold 2 will treat up to 350,000 tons per month of tailings for gold extraction.²

1. Mintails Limited 2009 Annual Report, page 7
2. Mintails Limited Quarterly Report - December 2009