Innovations John Chadwick has looked at include better options for comminution, new nickel leaching processes, ore sorting, better flotation, gravity separation, filtration and a new way to produce iron.
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one of the big concentrator completions last year was for Blue Ridge Platinum in South Africa. It was handed over to the client by Bateman Engineering in August 2009, operating at full capacity and processing 115,000 t/month of UG2 ore from the mine. Between 27 and 32 t of platinum concentrate are trucked daily for refining by Impala Platinum in an off-take agreement.

Awarded in May 2007, the $59 million lump sum turnkey project covered the engineering design, procurement and management of all construction activities and cold commissioning to a level at which the concentrator can receive ore. The concentrator is located near Groblersdal, in Mpumalanga, South Africa and was owned by Blue Ridge Platinum and subsequently sold to the Aquarius South Africa group.

Blue Ridge mine has resources totalling 5.34 Moz of PGMs and plans to produce 149,000 oz/y of six PGMs for 18 years. This comprises 75,000 oz of platinum, 35,000 oz palladium, 13,000 oz rhodium, 1,500 oz gold, 22,000 oz ruthenium and 2,500 oz iridium.

The award of the project followed plant prefeasibility and full feasibility studies, both carried out by Bateman Engineering. The flowsheet designed by Bateman closely resembles standard UG2 flow sheets developed in the early 1990s, being a well proven and enhance performance.

Additional benefits include a 20% reduction in weight but with no reduction in capacity, an opening to reduce material bridging. New arm shields and Spider cap provide it with improved protection.

Radical comminution changes

Hot on the heels of the innovative Nordberg MP1250 cone crusher covered in March International Mining, Metso has used the latest in design and modelling software for its newly created FEA models evaluated the strain gauge data from gyratory crushers in use, newly created FEA models evaluated the bottomshell for high stress areas and new solutions were found, resulting in increased reliability.

The redesigned single piece bottomshell reduces components and installation time. Using strain gauge data from gyratory crushers in use, newly created FEA models evaluated the bottomshell for high stress areas and new solutions were found, resulting in increased reliability.

The redesigned topshells were analysed using FEA tools to eliminate vertical rib stress risers while using horizontal bands to protect against concentrated loads. High strength banded construction provides trouble-free operation and the removal of vertical ribs has decreased stresses. Tapered flanges offer simplified construction.

The new rim liner retention system uses bars and clips welded in place. This arrangement connects all of the Spider rim liners together, making for simple, easily installed components. No bolts are required, making the rim liners easily replaceable and are tied together to act as one piece.

An additional feature of the SUPERIOR 60-110E is an upgraded mainshaft assembly with a patented bearing ring that releases the pressure of the headnut or mantle and affords simple replacement of one less expensive component. Metso’s first production 2,240 kW Vertimill®, known as the VTM-3000-WB, is destined for Newcrest Mining’s Cadia Valley Operations (p4 this issue), where it will be operated in a tertiary grinding role. Cadia’s concentrators in New South Wales already have several VTM’s operating in traditional regrinding roles, as well as a VTM grinding SAG product in parallel with a ball mill. Metso says the VTM “has been proven to grind more efficiently than ball mills with feeds
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Ore sorting - the ROM Secondary EM series of high speed machines is designed for simple operation and for use in remote areas. Commodas says “sorting applications increase efficiencies and lower a mine’s environmental footprint in the extraction of diamonds, gem stones, gold, platinum and other minerals. Optical, Electromagnetic (EM) and X-ray Transmission (XRT) sorters enable operators to separate waste rock from raw minerals, prior to the milling process, which increases yields and reduces operating costs.

Optical sorters involve linescan cameras and complex sorting software and hardware equipment. These sorters can separate minerals and waste rock if there are sufficient colour differences visible on the clean surfaces of the rock. For example, calcium carbonates (white) can be distinguished from shale (brown). With the latest XRT sensors, the sorter generates X-ray images of each and every rock flowing through the sorter. One literally looks inside rock to determine its composition and the presence or absence of especially dense metal-bearing minerals as coarse as 6 mm to products finer than 20 micron. It has become the industry standard in concentrate regind application, but has been slow to be adopted for large-scale coarser applications. The hesitation to advance VTMs in primary and secondary grinding is largely because more VTMs are needed to perform the same task as a single large ball mill. The new VTM-3000-WB, however, reduces the number of units required. Cadia is now able to get the grinding power it needs to meet the product size requirements with a single Vertimill.”

“The VTM-3000-WB is an enabling technology that allows operations like Cadia to get the maximum payback and profitability for their grinding projects,” says Jonathan Allen, Metso’s Vertimill Product Manager. “It has all of the same components and therefore the same advantages as smaller VTMs, but with the added advantage of lowering total capital cost and maintenance.”

The Cadia Valley operations are based on a large, low-grade ore deposit requiring high throughputs to maintain profitability. Current capacity at Cadia is 17 Mty and for Ridgeway 5.6 Mty. The near surface ores are becoming worked out, so to ensure the longer term future at Cadia Valley, Newcrest is developing the two Ridgeway Deeps and Cadia East underground projects. The changing ore feed to the Ridgeway concentrator necessitates additional grinding power.

According to Leigh Cox, General Manager of Newcrest’s Cadia Projects, additional grinding ultimately means improved recovery. “The VTM-3000-WB allows our high grade plant to operate at a higher throughput rate, or attain finer grind”

In addition to the process advantages of the Vertimill, the project also had space limitations, so the small footprint of a single VTM made it a good solution. The VTM was delivered mid-March 2010 and should be commissioned by the end of June. Installation support and process commissioning services are included in Metso's contract.

**Future base metal recovery**

Work by the Minerals Down Under Flagship has shown conventional concentrating and smelting may prove to be the most sustainably appropriate processing routes for copper and nickel as ore grades fall. This is the case when pyrometallurgical processing is suitable and where no additional grinding is required, according to CSIRO Senior Project Engineer Terry Norgate, a specialist in using life cycle assessment (LCA) to investigate and evaluate the environmental impacts of processes.

However, he found that the most appropriate processing option changes if fine grinding (down to 5 micron) is needed. Instead the best processing route is heap leaching and direct smelting for copper ores and in-situ leaching for nickel ores.

With the lower-grade ores expected in the future likely to need extra processing, sustainability concerns are becoming more prominent. It prompted Norgate to try to identify the most sustainable processing routes for these ores in energy consumption and greenhouse gas (ghg) emission terms.

“Falling ore grades and more complex orebodies anticipated in the future can be expected to lead to increased energy consumption and associated greenhouse gas emissions for primary metal production,” he says, with sustainability concerns seeing the mineral processing and metal production sector come under increasing pressure to address these issues. “But choosing the most appropriate processing route for low-grade ores is not always clear.”

Norgate used LCA to examine various processing routes to extract metal from low-grades – down to ores containing less than 0.1% metal. He examined conventional concentrating and smelting, direct-ore smelting, heap leaching, pressure leaching and in-situ leaching for copper and nickel ores to answer the question: ‘What’s best for low grade ores – melting, leaching or concentrating?’

The study results suggest that no definitive answer can be given to that question, with the most appropriate route for processing low-grade ores – in terms of embodied energy and ghg emissions – largely dependent on the ores’ mineralogy. Also, Norgate says that this “firstpass comparison” of various processing routes did not include economic considerations. “Such issues will strongly influence the route eventually chosen,” he says.

The potential impacts of some emerging technologies, which could also influence the route chosen, were not considered. These include:

- **Ore sorting** – which could be used to reduce the amount of ore (and hence energy) required for direct smelting
- **Waste heat recovery** – for example, from smelting slags, mattes and other by-product streams – which could be used to reduce the energy consumption of both the conventional and direct smelting routes.

“Although there is often very little choice as to which processing route is used – because this largely depends on ore mineralogy – the results showed what the most sustainable routes are..."
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likely to be as ore grades fall.”
Terry.Norgate@csiro.au

New laterite heap leach
The CSIRO is working with the universities of South Australia (through the Ian Wark Research Institute), Queensland, Melbourne and British Columbia to examine ways of enhancing heap leaching of nickel laterite. These tend to be lower-grade and are complex and expensive to treat using conventional methods.

Heap leaching is a promising next generation technology that offers a potentially simpler and less costly processing alternative. However, significant technical challenges are preventing the adoption of heap leaching, including excessive acid consumption (caused by unwanted side reactions) and maintaining high permeability within the heaps.

This work is looking to overcome problems associated with the lower-grade deposits through the development of radically new and improved pretreatment and agglomeration methods. John.Farrow@csiro.au

In late December 2009, Western Areas acquired the BioHeap leaching technology from Pacific Ore. Due diligence included a successful test work program on a range of low grade ores from Forrestania, an evaluation of global patents on the technology and confirmation of various commercial aspects. Western Areas took on five specialised technical and commercial staff from Pacific Ore to progress the application of the technology to Western Areas projects. In addition, Graham Marshall, previously the General Manager of Pacific Ore became General Manager - Commercial for Western Areas.

BioHeap uses bacteria to leach lower grade sulphide ores to produce intermediate products which can be sold directly to nickel refineries. A large amount of test work has been carried out on a wide range of nickel deposits around the world and BioHeap has been successfully applied to low grade ore at the Radio Hill nickel mine in the Pilbara.

A 280-hour-long, small-scale pilot operation involving CSIRO researchers and Rio Tinto staff has ‘proved in practice’ CSIRO’s direct solvent extraction (DSX) process to recover nickel and cobalt from laterite leach solutions.

The successful operation was stage five of a journey that Minerals Down Under Flagship researchers – working through the Parker CRC for Integrated Hydrometallurgy Solutions – and Rio Tinto Technology and Innovation staff have taken to further develop the technology to suit Rio Tinto’s leach solution and to test how well it works.

Lead scientist, CSIRO’s Dr Chu Yong Cheng, says stage five is the most important for any new SX process. Called the fully continuous stage it is essentially a small-scale pilot operation. “A lot of effort went into this operation: it was run continuously with extraction, scrubbing and stripping, over two shifts a day with hundreds of samples taken.”

However, that effort was justified because its success means the process has been proved “in practice and not just in principle”, he says.

Mark Godfrey, Rio’s Principal Adviser for Hydrometallurgy, says DSX offers a simple and selective process for the full recovery of the nickel and cobalt from nickel leach solutions.

The core of the DSX process is the CSIRO-developed synergistic solvent extraction (SSX) technology, which Rio had earlier identified as a possible way of streamlining nickel processing.

SSX uses organic solvent reagents to directly separate nickel and cobalt from impurities including magnesium, calcium and manganese without intermediate precipitation and re-leach steps, and does so with high selectivity, simple process flowsheets and potentially low capital and operating costs.

The latest stage in testing the SSX technology involved further optimising operating conditions for extraction, scrubbing and stripping in a fully countercurrent operation mode and collecting data for plant design and operation. It followed on from previous work, including batch and...
Cheng says the latest results – now being evaluated by Rio Tinto – could be used for further, larger-scale pilot work, plant design and operation. “More test work could be carried out to further improve the operation and accumulate more data for plant design and operation.”

Godfrey says the nickel and cobalt recovery results are very good. “Confirmation that there is no gypsum precipitation makes this an outstanding process and continued testing and development of DSX for nickel laterite processing is warranted.” Chu.Cheng@csiro.au

**Better flotation**

There is a new reagent supplier with some very interesting ideas – Flottec. Fundamental to its philosophy is a shift from a focus on specialty chemicals (which are manufactured by strategic partners around the world) to a focus on specialty service. What this means is that the emphasis has shifted away from the development of new specialised reagents to how chemicals are applied. The company states its mission “is to develop, manufacture and market specialty chemicals and flotation technology to the global industry.” Their emphasis is on applications technology as the means to optimise circuits, not the chemicals themselves.
Flottec aims to support its mining chemical products with superior applications technology and on-site service

Flottec's business objective is to become the industries preferred mining chemicals supplier through the execution of superior in-house manufacturing, sales and technological capabilities.

“In partnership with leading global manufacturers and service providers, Flottec will supply competitively priced, value added, flotation reagents and processing aids. But more importantly, Flottec will support our mining chemical products with superior applications technology and on-site service that will meet our customers’ needs for improved performance and lower costs.”

At the heart of Flottec’s philosophy is the intent to offer “processes for systematic understanding of the mill circuit, customised products, applications optimisation and operator training for each individual mill.”

Frank Cappuccitti, Flottec President explains that “the development and application of chemical technology over the last 20 years has been characterised by the promise for the improved performance and efficiency of the operating mill through great innovations. However, many promising programs to develop new reagents or to better apply current products have not been able to be translated to improvement in the plant. The development of a new concept from lab testing through plant testing to practice while coping with the complexities of the processes used in mineral beneficiation has proven to be very difficult. The problem is that too much focus has been put on the development of new reagents instead of the proper application of current products using new control technologies by operators who understand how to best use the products.”

Flottec has achieved great value by conducting R&D in applications technology in conjunction with premier universities such as McGill where together great advances in fundamental knowledge have been made, especially in the understanding of frothers and their effect on cell hydrodynamics. It is also outsourcing its manufacturing and together with its affiliate in China, Florea, is using representatives like Sinoz in Australia, Chemiqa in Canada, Mercantil in Peru, OxiQuim in the rest of South America and other regional suppliers to bring the products and services to market.

Flottec has manufacturing capabilities in the US for frothers and processing aids. It has also built relationships with the world’s largest and most cost efficient manufacturers of sulphide collectors, including two of the newest manufacturing plants in China - Humon and Shenyang Florea - and supplies the world mining industry with its full range of flotation reagents: collectors, frothers, activators, depressants and processing aids.

Last year ABB’s Expert Optimizer was used to automate Boliden’s zinc flotation circuits. The Garpenberg plant in Sweden is benefiting from successful application of Model Predictive Control (MPC) to a complete flotation circuit.

ABB says it has successfully applied its award winning Expert Optimizer solution to the zinc flotation circuits of Boliden’s Garpenberg plant in Sweden. The solution applied MPC to help to stabilise the overall process, and maximise zinc recovery.

ABB and Boliden have a long track record of successful collaborations in the field of automation technology and agreed to collaborate on a project to apply MPC to a complete flotation circuit. The aims were twofold. Firstly to stabilise the process to compensate for external factors, such as ore quality changes. Secondly, the zinc revenue should be maximised, through maximised recovery and higher concentrate grade.

Successfully optimising the circuit required that three criteria be met. First, the behaviour of the process had to be predicted using a reliable dynamic model of the flotation circuit. Then cost functions and finally operating constraints were incorporated in order to produce a robust MPC application.

In order to achieve certainty with regard to the controller benefits, a measurement campaign was started at the end of 2008 and finished in the middle of 2009. The results showed that concentrator efficiency (directly corresponding to revenue) was at least 1% higher when MPC was used, compared with the existing manual control strategy. In addition, the zinc concentrate grade has been higher and more consistent, while the recovery has remained at the same level.

Henrik Lindvall, Process Engineer at Boliden, Garpenberg, said, “Following the successful testing period, Boliden is continuing to use Expert Optimizer on their Garpenberg zinc circuit and has continued to report good results throughout 2009”.

Expert Optimizer, part of ABB’s cpmpPlus suite of applications, is the recommended tool, by ABB, for implementation of advanced process control in general, and MPC in particular, in mineral processing. In addition to the general framework for MPC, Expert Optimizer also includes tools for implementation of soft sensors and artificial intelligence applications.

Well known in flotation and many other processing areas, Outotec is establishing a new operations model. President and CEO Perrii Korhonen says the objective “is to expand the offering and increase value capture in our current core business of minerals and metals processing solutions and services. In addition, our objective is to grow in new businesses such as energy sector and industrial water treatment.”

Outotec has been reorganised into four business areas:

- Non-ferrous Solutions, consisting of businesses relating to the processing of copper, nickel, zinc, lead, gold, silver and platinum group metals as well as industrial minerals
- Ferrous Solutions, consisting of businesses relating to the processing of iron, steel and ferroalloys as well as titanium feedstock
- Energy, Light Metals and Environmental Solutions, consisting of businesses relating to sulphuric acid plants, gas cleaning, alumina, aluminium and light metals processing,
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Establishing a mining operation can present a dilemma. On the one hand, budgetary pressures can increase the appeal of equipment with a low initial cost.

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Cyanide management

Mintek started cyanide investigations with the advent of the CIP process for gold recovery in the 1980s, and has been at the forefront of cyanide management since. An advanced gold leach facility was recently commissioned to monitor leach process parameters such as pH, Eh, oxidant addition, pulp viscosity, and cyanide concentration, and their effect on the leaching kinetics of the target metals as well as the environmental parameters. It serves the dual purpose of identifying the optimal leach parameters while generating data regarding the environmentally harmful species such as cyanide, arsenic and heavy metals, which are tracked in real time as the leach progresses.

Mintek’s Cynoprobe can measure both ‘free’ and weak acid dissociable (WAD) cyanide concentration of up to two independent streams. This results in a very cost-effective cyanide measurement solution. It uses an amperometric technique to accurately and reliably measure the cyanide concentration in a pulp medium. Fast, reliable measurement allows for rapid detection of changes in cyanide concentration. Other features include:

- Minimal maintenance of the filter probe, automatic air cleaning prolongs the filter maintenance cycles
- Automatic calibration and cleaning cycles
- Appropriate for CIP, CIL, RIP, RIL, heap leach, backfill and cyanide destruction circuits

One area covered by the International Cyanide Management Code, which is administered by the International Cyanide Management Institute, relates to regulation of the level of cyanide contained in the tailings being discharged from a plant into the associated tailings facility. The Code currently stipulates that the WAD cyanide levels exiting the processing plant must be less than 50 ppm. As the majority of gold operations tend to be higher than this it is then necessary for the operation to include an additional cyanide destruction stage in the overall process flowsheet.

Whilst there are several commercial processes for cyanide destruction they all tend to be relatively expensive, according to MMS, “often involving the use of exotic reagents at high addition rates with a high installed capital cost. Associated control systems are often complex and not ideally suited for more remote operations relying on local labour.

“High gold grade high recovery operations may be in a position to absorb the higher costs associated with cyanide destruction. However, for lower grade operations or those increasing throughput with additional marginal ounces, cyanide destruction costs can become prohibitive.”

The MMS CN-D process uses oxygen addition in MMS’s proprietary mass transfer reactors in combination with an activated carbon contact stage to efficiently and economically destroy all forms of cyanide through an oxidation process. The addition of a catalyst can result in a further reduction of strong acid dissociable (SAD)
Today’s production challenges require a rethink of conventional processing methods and a reinvention of more creative and cost-effective approaches to abrasive applications. Linatex builds on its history of more than 80 years in the process equipment industry to innovate fresh, yet field-proven processing solutions for aggregate and mining operations worldwide.

The latest result is the newly-designed Linatex Process Equipment Range which includes valves, hard metal and rubber pumps, dewatering screens, and hydrocyclones. Lined with Linatex premium quality, abrasion resistant natural rubber as standard and custom engineered for a limitless range of wet, dry, sticky, high impact or highly abrasive applications.

**Lowest Cost of Ownership**
Linatex is recognised as the global leader in premium quality natural rubber products for abrasion, impact and corrosion resistance. Bottom line, by combining unsurpassed wear resistance with improved and integrated processing systems, the new Linatex Process Equipment Range offers the lowest cost of ownership and the highest return on investment. Among many, consider just a couple of examples:

**Regarding a bentonite recovery application in construction sand:** A Linatex G4 Hydrocyclone provides a much sharper classification of fine materials when compared to standard hydrocyclones. Lined with 10mm natural Linatex Premium Rubber, the unit delivers 80% savings by maximising the service life of the equipment between changeouts, dropping the cost of ownership to 20% of that of equipment lined with conventional rubber.

**In a gold mining application:** A Linatex Pinch Valve is installed in a vertical position, where due to many open and closed cycles, maximum wear resistance is required. A double acting pinch mechanism closes the pinch sleeve along the valve centre line to minimise wear damage to the sleeve liner, which is comprised of natural Linatex Premium Rubber. The extended wear life resulted in 75% savings over the use of a conventional valve and sleeve.

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The exact chemistry of the process is complex but basically involves the oxidation of cyanide to initially cyanate and then finally to a mixture of ammonia, carbonate and urea with the exact composition depending upon the conditions used. Under normal conditions reactions are very slow but are accelerated in the CN-D process through the use of the aachen reactors and activated carbon to further decompose the cyanate.

The process has a major advantage in that it incorporates standard plant CIP tanks and screening systems in combination with the aachen reactors. These reactors used for the oxidation process are the same as those used in MMS Leachox™ process. This is obviously beneficial for those operations already using Leachox or intending to use it.

Apart from its inherent simplicity an additional benefit of using activated carbon in the CN-D process is that it effectively increases the installed adsorption capacity of a plant contributing towards an overall soluble loss. Even well controlled plants can at times suffer process imbalances resulting in spikes in gold lost to solution tails. The CN-D then acts to capture these spikes. The additional gold thus recovered can be offset against the already low cost of the process. Where plants are kinetically constrained the additional gold recovered may even totally offset the cost of the CN-D. One additional consideration often overlooked when investigating different processes for cyanide destruction is to only focus on the tail end of the leach. A lower cyanide addition to the leach feed can not only result in cost savings but also a lower cyanide tail for subsequent destruction. Here again the leachox process can significantly reduce cyanide consumption through effective pre-oxygenation and acceleration of leach kinetics. This is particularly important for refractory orebodies although the benefits are not solely limited to refractory ores.

Gravity recovery
Knelson Gravity Solutions, in association with Appropriate Process Technologies, Johannesburg, has recently installed and commissioned a plant in Colombia for the recovery of gold and platinum from alluvial ore.

The client has a progressive fresh agenda and was desirous of a facility that was not only more efficient than the standard riffle systems being employed, but also environmentally friendly. After site testing to characterise the material, the Knelson technical team decided upon using the tried and proved Knelson CD system for simplicity whilst still satisfying the requirement for enhanced security. The APT scrubbing plant was chosen to deal with the tenacious clay content of this ore, having been developed specifically for the process.

The plant incorporates a number of novel features including a ‘real time’ visual assessment of production results via a Gemini Table. In this way, the grade of the source material can be assessed every four hours to confirm yield, and therefore supply grade control information back to the mining operation. The unit is self contained with its own water tank and power generation. All that was required as pre-preparation was a concrete slab on site.

Gekko Systems’ InLine Pressure Jig (IPJ) is much faster and far more efficient than the original gravity separating techniques used by oldtimers, such as panning, sluicing and dry-blowing. So, Gekko wanted to better understand the science inside the device in order to optimise its performance.

CSIRO’s computational fluid dynamics (CFD) team took up the challenge. Gekko wanted to know what happens inside the closed world of its IPJ in order to provide a more detailed description to its clients and market it more successfully.

Dr Chris Solnordal, Project Leader and a senior member of the CFD team, explains they constructed a computer model that replicated
the IPJ’s internal workings. “We had to incorporate into the model all of the factors at work in the jig, from the round shape of the vessel, the nature of the slurry being injected, the flow rate, and the effect of a pulsing (or jiggling) action on the slurry.

“The result is a model that explains why Gekko’s IPJ achieves high recoveries of both fine and coarse mineral particles.”

He says one of the most important factors revealed in the computer modelling was the circular shape of the vessel itself and the central slurry injection point from which slurry disperses in all directions. “As the slurry slows down there is a greater opportunity for the gold to drop out onto the ‘gold pan’. Other jigs lack the circular shape and are more like long channels, so the flow rate across the screen where heavy material falls out stays constant … it’s not spreading out, it’s like water flowing down a river.”

As the gold drops out of the slurry it falls onto a screen covered in ragging (a layer of rocks or lead shot), which is pulsed, causing the auriferous material to percolate down into a hutch – a conical region with an exit chute and pipe – for extraction and possible reprocessing for enhanced separation, or as a finished product.

Solnordal says other factors at work in the Gekko IPJ include encapsulation of the process. This meant it could be run under pressure, facilitating faster pumping and processing while eliminating the gas-liquid interface where particles might otherwise accumulate.

“Through our modelling, Gekko can see whether the IPJ is operating the way the company thinks it is and possibly find ways of improving the design.”

The CFD model produced is essentially a Gekko jig built inside a computer, with key inputs including a liquid the density of gold-rich slurry entering a circular vessel at a specified flow rate, which is then tracked to see how and when heavier particles, such as gold, drop out.

“The important part was being able to model the jiggling motion of the screen, so we included the ragging and the characteristic shape of the bed of material on the ragging. What we learned is that encapsulation and pressure caused a recirculation of the slurry. Heavy material was falling down as you would normally see in this type of gravity-based system, but in the Gekko jig there was also a pulsating recirculation that showed the material flowing back in and not just out.

“That meant finer material, which might otherwise have gone to the tailings as waste, was being encouraged to move back into the system, increasing residence time and capturing more gold.”

Better filtration

Professor Antti Häkkinen from the Department of Chemical Technology at Lappeenranta University of Technology (LUT) in Finland says “we offer the best expertise in separation technology in Finland.” He also notes “the co-operation between Larox and LUT is extremely close, even in international terms. Our policy of working together with companies is embodied in the motto of the LUT Centre for Separation Technology (CST): AbsoLUtely Creative, Solutions, Together.”

Larox signed on as a corporate partner of CST in 1999. Larox Chairman Timo Vartiainen had been appointed Chairman of CST the year before, and he continues to serve in this position.

“The co-operation between Larox and the LUT Centre for Separation Technology has contributed significantly to the success of both parties,” says Vartiainen. “We at Larox have been able to utilise the university’s basic research and scientific expertise, while supporting the inclusion of separation technology as one of the strategic areas of expertise at the university. Over the years our co-operation has continued to deepen and evolve. Larox currently has several long-term development projects in progress that will generate a real competitive advantage for the company in the coming years.”

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Häkkinen has held the Larox-sponsored Professorship in Solid-liquid Separation Technology since the beginning of 2008. He is responsible for the details of the co-operation on behalf of the university and for overseeing the resulting research projects. “Our co-operation has ensured that solid-liquid separation technology is one of the most important subjects taught and studied at the Department of Chemical Technology. The financial support of Larox has allowed us to recruit new research personnel and to develop our readiness.”

The Larox-LUT partnership has allowed the research team to hire specialists and acquire deep expertise. “For the university it is important that our corporate co-operation generates theses. Researchers have the opportunity to utilise Larox projects for their graduate work, and we expect the first such doctoral thesis to be completed in 2010. Basing research on real and challenging industrial problems is very positive, and it clearly motivates the researchers themselves. Our long co-operation with Larox has also increased awareness among our researchers about Larox filters and customer needs. Larox is a global leader in its field and thus a highly valued partner for us. We would be very proud if Larox was able to solve real problems and improve its processes thanks to research carried out by our university,” Häkkinen adds.

### Hydromet indium recovery

Adex Mining reports the successful development of a process for the production of high purity indium at its Mount Pleasant mine property in southwest New Brunswick, Canada. Adex overcame a major hurdle at the close of 2009 by producing the first few grams of indium in its bench-scale hydrometallurgical process development program.

The bench scale process development work completed by mid-January indicated that the process was capable of producing indium in excess of 88% purity. Bench scale optimisation of process chemistry to confirm design parameters for the hydromet pilot plant test work is ongoing.

The hydromet process, developed by Thibault & Associates, an Adex consultant, involves leaching base metal sulphide concentrate containing approximately 4,500 ppm indium and recovering the indium and zinc through a series of SX and solution purification processes. Adex is considering patent applications with respect to certain aspects of this technology.

Indium production potential at Mount Pleasant is about 40 t/y based on processing 850 t/d of mill feed. Adex is considering two commercial production scenarios there. Under the tin concentrate, indium and zinc metal production model, there is also potential to produce about 4,000 t/y of zinc metal and 3,200 t/y of tin concentrate from the North Zone (NZ). Under the tin concentrate and zinc-indium concentrate production model, there is potential to produce about 8,500 t of indium rich zinc concentrate and 3,200 t of tin concentrate from the NZ.

### Iron ore

Iron ore developments continue apace, particularly in Australia where MSP Engineering (formerly known as McSweeney Partners) has acquired the Australian and New Zealand agencies for allmineral Processing Equipment. allmineral designs and manufactures alljig®, allflux®, allair® and gaustec® high efficiency process equipment specifically designed for beneficiation of minerals susceptible to gravity and/or magnetic separation.

The alljig unit is ideal for beneficiation low grade iron ore deposits particularly hematite style ore deposits as found in Western Australia. As previously reported in IM, the technology has already been installed and proven on large production scale at Kumba’s Sishen Iron Ore Expansion project in South Africa which has a rated capacity of over 4,000 t/h and where 24 alljig units are installed. Large scale production facilities using alljig technology are also currently under construction in India.

The allflux classifiers are the largest production units on iron ore beneficiation worldwide, with a number of smaller units already installed in Western Australia. The largest units can handle over 300 t/h of minus 2 mm feed material on iron ore and allmineral is currently considering developing larger production units.

The gaustec WHIMS separator is the largest of its kind in the world with rated capacities exceeding 200 t/h and a top size capability of up to 3 mm feed material.

The units have been developed in Brazil and have been extensively installed throughout the country in fines iron ore dressing facilities. They’re opposed to oil coiled units whilst still developing the same magnetic field strengths.

MSP Managing Director McSweeney believes the application of one or the combination of all three technologies provides superior solutions to iron ore producers contemplating downstream, value adding of low grade DSO iron ore deposits. The industry is recognising that the resource size can be greatly enhanced and extended if it can find cost effective, simplistic processing solutions which maximise yields whilst maintaining product quality and grades.

“it is most likely that the raft of junior and mid tier iron ore exporters and emerging producers will apply the technology in the first instance, whilst the majors undertake a longer term view on technology application, however in final analysis downstream beneficiation of most DSO deposits is eniable and we feel we have the latest and most effective technology in low cost processing solutions which is already demonstrated in large scale industry applications”, McSweeney added.

The technology is also very suitable for most industrial minerals requiring beneficiation which is susceptible to gravity and magnetic separation particularly in the coarser size ranges.
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MINERAL PROCESSING ADVANCES

Clean iron nuggets
The world’s first commercial plant using the ITmk3® Process successfully began production of iron nuggets in the US on January 12. The next-generation process was developed by Kobe Steel. Kobe Steel and Steel Dynamics (SDI), constructed the plant at Hoyt Lakes, Minnesota. Production of iron nuggets, which are used in steelmaking, will gradually increase in accordance with operating conditions and is anticipated to reach the facility’s annual design capacity of 500,000 t in mid-2010.

ITmk3 is an innovative next-generation iron-making process, totally different in concept from the traditional blast furnace method. Since the initial work in 1994, the process has undergone many stages of development and is now notable for the following characteristics:

■ High-grade iron nuggets can be produced in an extremely short time of about 10 minutes
■ It can use lower-cost iron ore fines and steaming coal, which are difficult to use in blast furnaces
■ In comparison to the pig iron produced in a blast furnace, the production of iron nuggets using the ITmk3 Process emits about 20% less carbon dioxide due to its good energy efficiency.

With the start up of the commercial ITmk3 plant, Kobe Steel is moving quickly to expand the technology’s use on world markets. Kobe Steel is working on iron nugget projects in North America, Vietnam, India, Russia, Australia and other countries, a cumulative production capacity of several million tonnes of iron nuggets.

Over the medium- to long-term future, steel demand is anticipated to continue increasing. Accordingly, electric-arc furnace steelmakers are faced with a growing need for cold iron units, namely clean iron units such as blast-furnace pig iron and direct reduced iron (DRI). Kobe Steel believes the ITmk3 process is one of the most effective ways to meet this new demand.

The process, with its lower CO2 emissions and capital investment, is highly suitable for growing environmentally friendly steel industries in developing countries. It can use cheaper low-grade iron ore and coal, keeping raw material costs down. Along with these advantages, the real value of the ITmk3 Process is that it produces high-grade iron nuggets with better meltability than blast-furnace pig iron when used at the steelmaking stage.
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ITmk3 enables mining companies to produce iron nuggets to add value to their natural resources. As a result, they can expand their markets to include electric-arc furnace steel makers, in addition to their traditional customers with blast furnaces.

Grappling with environmental issues, the world steel industry faces a tight raw material market and higher costs due to the sharp increase in steel production. Under these conditions, ITmk3 is an attractive alternative. Kobe Steel, with subsidiary Midrex Technologies, is the world’s leader in DRI processes. Its Midrex® process is used to produce nearly 60% of the world’s DRI.

SDI plans to use the nuggets produced by the Minnesota ITmk3 plant in its steel mills.

The ITmk3 process:
1. Pulverised iron ore and pulverised coal are agglomerated into ball-shaped pellets
2. The pellets are fed into a rotary hearth furnace. Reduction, melting and slag separation occur in about 10 minutes
3. The resulting product is high-grade iron nuggets.

Raw material pretreatment facilities (coke ovens, sintering plants and pellet plants) are unnecessary. ITmk3 is suitable for mining sites and can even be profitable for small mines. Its operation is easy and production adjustments are simple.
The iron nuggets are slag-free, high-purity iron units of the same quality as pig iron. They have a metallic Fe content of 96% to 97%. They are easy to transport and handle. High in density, they do not re-oxidise or generate fines.

Process control
Tom Noble, Schneider Electric, Metals, Mining and Minerals Business Development Manager notes that “risk is the primary factor in determining whether or not to upgrade a control system in any facility. This decision can be both a deterrent and an incentive. If equipment and processes are functioning as designed, putting the business at risk for incremental performance improvements by implementing a new solution may be short sighted. Conversely, variables such as aging equipment, personnel safety and concerns of lost profitability due to machine downtime may change perceptions quickly and make not migrating even more risky. That was the situation for one of Newmont’s major facilities, Mill 6, located on the Carlin Trend in Nevada, USA.” It has been in operation since 1994 and in 2007, Newmont Mining made the crucial decision to begin the process of upgrading the control system to ensure future years of continued service, support, reliability, and component availability.

This required an intensely managed control system migration which was completed in May of 2009. The migration project included a simulated test of the complete system conducted jointly with Newmont and Schneider Electric Engineering staff. The legacy system comprised of 12 Modicon 984-785E hot standby programmable logic controllers (PLCs). The replacements were 12 Modicon Quantum hot standby PLCs. The task was completed in less than two weeks without an incident or delay. The result is a state-of-the-art control system using Quantum Hot Standby processors and redundant dedicated Ethernet peer-to-peer communications networks while still maintaining the redundant legacy Modbus Plus SCADA and remote PLC networks. This has now positioned Newmont to upgrade I/O as time and economics permit.

Newmont Mining’s Mill 6 plant is a gold whole-ore roasting operation with nominal throughput of 9,300 t/d of ore. The heart of the facility’s control system was 12 pairs of Modicon 984-785E hot standby PLC’s using a redundant D908 network for interlock communications between each PLC and a master data concentrator PLC. The most advanced PLCs available when the facility was designed and commissioned, these Modicon PLCs provided motor controls, loop controls, SCADA, operator advisories, and managed all critical interlocks for the facility. Operating in pairs with a primary controller and a standby, the Modicon 984-785E PLCs successfully maintained consistent, reliable operations for the Mill 6 plant which include ore grinding, ore pre-heating, ore roasting, gas cooling, waste heat steam production, gas cleaning, water management, acid plant, and ore quenching processes.

In 2007, despite still performing as designed, Newmont made the decision to upgrade its Modicon 984-785E PLC-enabled control platform and D908 communications network. The age of the equipment that made up the control platform and network, coupled with the inability to readily purchase replacement components, drove the decision.

“Our Modicon 984-785E PLCs did their job, and could have for many more years,” said Dirk Danninger, Carlin Process Control Manager at Newmont Mining. “But as with all things, you need to look to the future and prepare for change. We needed to migrate out of the D908 topology to a more standard one as this technology is obsolete. We wanted to migrate in a methodical controlled fashion as opposed to being forced into an unscheduled migration due to a lack of replacement parts.”

Adding to the challenges inherent with any migration project was the inability to shut down production to perform the actual work. The Mill 6 plant is operational 24 hours per day, seven days per week for all but three

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weeks of the year when routine maintenance is completed. Even during the scheduled maintenance interval, the PLCs still control cooling water, plant and instrument air, potable water, and are required for instrumentation and electrical preventative maintenance procedures. This meant that the upgrade would have to be implemented within the annual outage window while not impacting the maintenance schedule of the facility.

Newmont's management understood the risk of the upgrade and turned to Schneider Electric when it came time to choose a partner to assist with the Mill 6 plant's control system migration. The facility's success with Schneider Electric's Modicon 984-785E PLCs gave Newmont a foundation from which to start, and in 2007, company officials began discussing with Schneider Electric a blueprint for migrating the legacy PLCs to new Quantum PLC counterparts. A critical component of the project was transitioning the existing D908 communication networks to Ethernet. Thus, a team of Schneider Electric's engineers from around the world began developing the proof of concept with Newmont's technical staff.

Working at the Schneider Electric Technology and Solution Center in Raleigh, North Carolina, USA, automation experts and Newmont technical staff configured the complete system as would be installed at the facility (without I/O) for testing and proof-of-concept purposes which included minor logic changes to support the D908 replacement. The testing procedures included the critical hot standby switchover process demonstrating bumpless control and communications that would enable Newmont Mining to make the transition with confidence from its legacy Modicon 984-785E PLCs to new Modicon Quantum PLCs. Engineers from both Newmont and Schneider Electric introduced faults into the control system to simulate critical component failures that could result in a plant crash. The hot standby control system took over program execution without incident in all test cases. Consequently, all 12 PLC nodes passed the rigorous tests from both engineering departments.

"The successful factory acceptance test was a milestone to our decision to move forward with the Modicon Quantum PLC upgrade." Danninger said. "Downtime was unacceptable, as was any delay in network communications during a component failure. Schneider Electric's ability to migrate our legacy system to a fully lab tested Quantum system in the allotted time was a huge success."

With a project blueprint in hand, system migration commenced in May 2009 with completion scheduled for two weeks later. A team of Schneider Electric field service engineers began the migration by replacing all standby Modicon 984-785E PLCs with Modicon Quantum PLCs. Plant personnel then shut down the primary PLCs, transferred cabling to the new Quantum PLCs, and started the new Quantum's which then resumed as the primary PLC, all within a two hour window. After the new Quantums were running as primary (all 785Es now powered down), personnel monitored processes for several days to ensure nothing unexpected occurred and that all systems were performing as designed. Satisfied, plant officials gave approval to replace the remaining 12 Modicon 984-785E PLCs such that all the primary Quantums would have their respective standby partner.

Ten days later, the facility was brought into full production without a single moment of downtime or process failure due to the upgrade. Additionally, Schneider Electric field service engineers performed testing and validation of the plant's remote I/O network system to confirm the ability to reuse the existing Modicon 800 series I/O.

Newmont Mining's Mill 6 plant now has a state-of-the-art control system that performs 50% faster, with robust redundant Ethernet communications, ensuring years of added productivity, safety and continued smooth operation.