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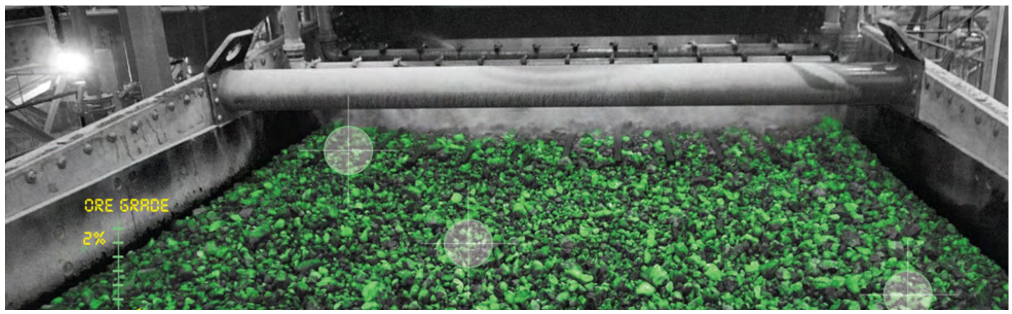
Field of vision

How supersensitive machines can stop you from processing waste

By Ian Ewing



"On average across the mining industry, 44 per cent of the total electricity consumption is dedicated to crushing and milling activities," reads the first paragraph of a 2014 study published in the journal Minerals Engineering. But how much of the material that is crushed and milled actually contains anything of value? Industry-wide, as much as 30 to 60 per cent of processed material contains no ore. Miners have found that they are able to drastically reduce energy expense and improve economics by using advanced sensing technology to weed out waste – a concept known as ore sorting.

Joe Lessard, a project engineer with Orchard Material Technology and lead author of the study, is one of a growing number of industry insiders who believe that ore sorting will deliver major changes to the way miners use energy. "There are no technologies that have the potential to actually upgrade the material to such an extent as ore sorting does, and with so little input cost," said Lessard. "The economic payback is so fantastic and so rapid that it's worthy of a feasibility study, it's worthy of the pilot-scale implementation, and then the scale-up to full-scale production."

The diamond and uranium sectors use the technology fairly extensively. But for most minerals, automated ore sorting has never achieved widespread acceptance, despite first entering commercial service in mining as early as the 1960s. The first generation of automated sorters earned a poor reputation due to low sensing resolution, poor discrimination, high capital costs and, most problematic, low material throughput. The technology was largely abandoned in mining before it ever really got started.

Sorting technology has chugged along since it was first introduced, slowly maturing and eventually finding widespread application in the food processing, recycling and scrap metal industries. Today, better sensors and increased computing power have helped make the technology more effective. And the changing economics of the mining industry have finally convinced mining executives to open the door when Lessard and others drop by to talk about this previously spurned technology.

Economic sense

"Three or four years ago, when we really started getting into the mining industry, we really had to push for those meetings," said Jason Looman. From his perch as president of Steinert US, a leading manufacturer of sorting machines, Looman has seen a major uptick in interest since then. "Now, rather than us calling them, the engineering houses and the end users are calling us and asking us to come out and talk to them about the technology, what it can and can't do. Even in the last six months, we've seen a big shift."

It is easy to see why. The industry is facing structural challenges that current mining methods simply are not coping with. "The price points are starting to make sense for sorting," explained Lessard. "The cost of electricity, the cost of water, and the cost of other utilities in the process all of a sudden point to a need for more efficient technology solutions. We can no longer just grind, grind, grind, because the cost of electricity is too high."

Andrew Bamber, CEO of Vancouver-based sorting start-up MineSense, sees even more behind the trend. "It's a perfect storm for a margin-enhancing technology right now," he explained. "You've got a combination of declining grades at existing operations worldwide, a scarcity of high-quality new discoveries, cost inflation driven by high input costs like energy, and prices that aren't high enough to support the current cost of doing business in mining."

According to Bamber, ore sorting is the natural remedy. "Mines in general, whether open pit or underground, are including a tremendous amount of waste material in what they call 'ore'. If you can eliminate that material, you can improve the basic economics of mining across the board."

Fundamental principles

Modern ore sorters are available with many sensing technologies (see sidebar on page 3) and sorting mechanisms, but the fundamental principle is similar in each: by sensing the composition of a volume of material or of individual rocks, waste material with little economic value can be identified and separated from valuable ore before too much money is spent processing it.

The traditional format is a belt-based machine that sits ahead of the grinding and milling circuits, analyzing – in nanoseconds – crushed and pre-sized run-of-mine material as it travels along a conveyor. A tenth of a second later, based on the composition of the individual rocks on the belt, an array of pressurized air nozzles diverts the waste material and ore into separate chutes as the rocks sail off the end of the belt. The cut-off grade is determined through feasibility studies prior to implementation, but can be easily recalibrated as mine plans and economics change.

Lessard, whose study examined the economics of ore sorting, points out that with adequately heterogeneous mineralization, diverting just a small percentage of waste rock provides significant value. In one case study he ran, spending $9.6 million to purchase and install a pilot-scale sorter on a side circuit quickly paid off, generating between $7 and $9 million in added revenue annually. "Even with what we would consider to be a crummy sorter, a sorter that is only rejecting 30 per cent of the feed as waste, you would still make all your money back in less than two years," he said. "It was surprising, even to us, to run the numbers and see just how profitable it actually would be."

One company betting those economics will pan out is Minera Alamos. The junior miner recently had to revisit the mine plan for its Los Verdes copper-molybdenum project in Sonora, Mexico. "The hang-up in the area is that there are no existing milling facilities nearby," said company president Darren Koningen. But by using an x-ray transmission (XRT) sorter to pre-concentrate the ore, hauling to a more distant mill has become economically viable.

"Instead of changing the mine plan so that we're only classifying ore that's more than, say, one per cent copper, and then losing all the sub-grade or mid-grade material," Koningen explained, "by putting the sorting equipment in place we can mine almost everything, and we'll use the sorter to reject all the crushed rock that's less than 0.5 per cent.

"We're looking at getting double the grade or more, while keeping our recoveries in the 90 per cent range. And it's 90 per cent of a bigger starting pool, because we're now mining more material – all that material between 0.5 per cent and 1 per cent that normally we would have thrown in the waste pile."

The earlier, the better

While reducing the quantity of material undergoing comminution can create enormous energy (and cost) savings, MineSense's Bamber prefers to intervene even earlier in the flowsheet. "In ShovelSense (MineSense's flagship product), we've developed a particularly transformational technology which allows mine operators to measure, report and decide about the grade of material at the point of extraction," he said. By outfitting the shovels and loaders themselves with all the necessary sensors and processors, operators can route ore for processing or to the waste dump immediately upon extraction, before undergoing any hauling or processing whatsoever.

"In the time it takes a scoop underground to take a load of material or a shovel on the surface to dig out the bench of material, we can take a bulk

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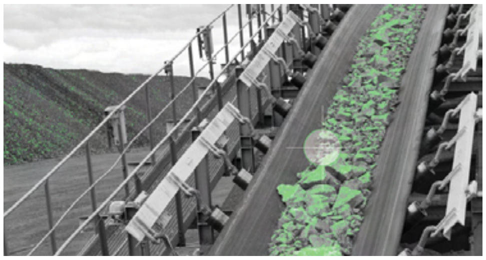
measurement, report the value, and compare it to the expected value," he touted. Current field trials show that his sorters confirm the existing mine plan around 70 per cent of the time. But the remaining 30 per cent of material – which would otherwise be misclassified and misdirected – represents an enormous loss of value (when ore is classified as waste) and increased cost (when waste is processed as ore). At one operation that MineSense has analyzed, a 50 per cent improvement to the current grade control and ore routing process would add $370 million to the net present value of the mine. As an added benefit, Bamber said, the real-time point-of-extraction sensing and classification can help improve the short-range mine plan as data is collected with every bucket load and transmitted wirelessly to production management systems. "Bulk sorting, the way we envision it based on shovel-based systems or bulk belt-based systems, directly affects ore body modelling, block modelling, grade assignation to those blocks and mine planning."



End-to-end process improvements

What the different philosophies and techniques all have in common is a capability to mine more material at lower grades, reject significant quantities of worthless material and pre-concentrate the crushed material before it gets processed.

In addition to using less electricity per ounce or tonne of recovered resource, ore sorting also decreases usage of consumables like water and reagents. A by-product of pre-concentration is a more uniform feed head grade, making downstream operations easier to manage and often improving recovery rates, explained Lessard. In the case of new plants, capital savings can be realized because a smaller plant is adequate for the lower volume of material, while retrofitting existing plants with sorting technology can result in decreased operating costs by taking unneeded units offline. And with less material getting milled into fines, tailings ponds can be smaller, mine lives may be extended and the ultimate environmental impact of an operation decreased.

There are other ancillary benefits, too: pre-concentration can increase the economically viable resource, increasing mine valuation. Production capacity and cutoff grades can be easily altered by the operator to meet market demands. And it can provide a new revenue stream, as the new waste stream from the sorters can be sold as aggregate.

The challenge of scale

While the gains made with sorting technology are significant, there are a few niggles and considerations still.

The heterogeneity of a deposit affects the usefulness of any sorter. "If the ore is widely and evenly dispersed so that every rock that comes out has roughly the same amount of the mineral of interest, sorting won't be helpful. What would you reject?" Lessard asked rhetorically. "But that's uncommon, over entire ore bodies. Anywhere there is clear mineralization, clear partitioning, ore sorting can have great value."

Knowing whether a mineral can be identified by sorting sensors is another problem – there are not yet any publicly available tables to determine which sensor technology to use for which mineral. But, said Lessard, "you should always do a feasibility or amenability study to test whether or not the ore will respond. You might dismiss sorting early because an ore won't work with XRT, but maybe it's a great candidate for x-ray fluorescence (XRF) or optical sorting. And until you try them, you can't really say definitively whether or not a sensing technology will work." Meanwhile, the list of ores that have been successfully sorted grows constantly (see sidebar) as manufacturers perform amenability studies with new sensing technologies, improved sensors and better algorithms on faster computers. Even minerals that cannot be sensed directly may be sortable, according to Steinert's Looman, if they are associated in the ore with a more amenable "tracer" mineral. Gold, which can be found by its association with quartz or with other metals, is one such example.

The longstanding complaint about throughputs has not been entirely solved yet, though. Throughputs are now in the range of 100-200 tonnes per hour per machine, an order of magnitude greater than just a decade ago. For large mines in some sectors, it is still not enough. "This technology isn't going to do 1,000 tonnes per hour from one unit," admitted Looman. "But you can create a circuit with the right number of units that would, and it can still be more economical than a plant without them." Many mines might see value just by adding a sorter to a smaller-capacity side circuit, too.

Anglo American Platinum (AAP) is one operator that has added "the right number" of units. Chris Rule, the head of concentrator technology for AAP, has overseen the construction of a US$5 million four-sorter proof-of-concept plant at Anglo's existing Mogalakwena North Concentrator facility in Limpopo Province, South Africa. Three years of pilot work with a single sorter at another facility in Johannesburg led to the new 25,000 tonne-per-month plant being built. It uses XRF to sense copper and nickel as a proxy for platinum-group metals (PGM). "Ore upgrading has been a strategic need for a number of years for AAP, and indeed for the [entire] PGM industry," Rule said. "The desire to produce fewer tonnes for more ounces is economically persuasive, especially in the face of lower grades and more difficult-to-process ores, above inflation, rising energy costs, and productivity challenges here in South Africa." Several months on, Rule added, the technology has shown the same value-creating results as the pilot tests, though he declined to discuss the numbers in detail.

A new order of sorters

"A lot of the problems with older sorters were engineering problems, not theoretical limits," concluded Lessard. "And inevitably, those technological limitations were worked through."

No one sorter is going to be effective at every mine site. But after performing amenability tests, and the field trials that manufacturers are often happy to do to prove their products' capabilities, a relatively simple economic analysis can determine if sorting is worth it.

"I really think sorting will become much more common," predicted Minera Alamos' Koningen. "It has the potential to impact both capital and operating costs, and I can't imagine these days that that's not what everybody is trying to do."

"Of any market I'm in, ore sorting has the highest growth potential," added Steinert's Looman. "I think it's on the edge of acceptance, especially based on the number of inquiries we're getting from the large engineering companies. Now, when the markets are down, is when you really have to find all the efficiencies you can. This is a way to do that." ■

Currently sortable minerals:

- Barite
- Calcite
- Coal
- Copper porphyry
- Copper-gold
- Diamond
- Gold (by association)
- Iron
- Lead
- Limestone
- Molybdenum
- Nickel
- Nickel sulphides
- Nickel-copper
- Phosphates
- Platinum
- Potash
- Rare earths
- Refractory metals
- Talc
- Tungsten
- Uranium
- Zinc

Sensing technologies currently in use, and what they're commonly used for:

- Electromagnetic (certain base metals)
- Magnetic (anything with magnetic properties)
- Near-infrared (NIR) (industrial minerals including calcite)
- Optical (anything with distinction in visual features, especially by colour)
- Radiometry (radioactive materials, especially uranium)
- Ultraviolet (UV)
- X-ray fluorescence (XRF) (surface sensing)
- X-ray luminescence (XRL) (surface sensing, for diamonds)
- X-ray transmission (XRT) (probably most versatile: best for base metals; for bulk-sensing, anything with different atomic densitie