Staying on Top of Stockpile Management

Smarter, quicker solutions emerge for measuring and controlling stockpile size and quality

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As part of a contract valued at $170 million, thyssenkrupp will build and install two stockpile stackers and a reclaimer for BHP's South Flank iron ore project in Western Australia. Shown here are similar machines at work in BHP's Mining Area C. (Photo: thyssenkrupp)

In tradition-driven industries like mining, deep-rooted habits and customs die hard. Pre-digital-world miners might have mistakenly equated task familiarity with productivity, while managers could lean heavily on institutional memory to plan projects and budgets. But things change: Big Data is driving the industry down a path in which old policies and practices are regarded with suspicion and new sources of information shine bright lights into the dim corners of conventional mining business intelligence. In the process, one of the most mundane links in the mining chain, stockpile management, is being polished by technological tools to a higher level of operational luster.

Stockpiles fulfill a number of functions ranging from alleviating feed-flow interruptions at process plants, to blending of various ore types or storage of low-grade or problematic ore for future disposition. At one end of the application spectrum, existing stockpiles at defunct mines are processed to provide an early source of income for new mine exploration and development, while at the other end, shipping-terminal stockpiles represent a near-final step in the quality-control chain before mineral products are delivered to the customer.

In line with an industry-wide interest in maximizing asset utilization, producers are taking a closer look at how stockpile management can improve key metrics such as plant utilization versus plant availability ratios. They are refining their stockpile strategy, taking advantage of equipment and control-system advances to refresh stockyard infrastructure, and, through improved material flow and quality control, reinforce their capability to maintain market share of their products. High on the list of upgrade objectives are automation of all or part of stockpile operations, replacement of aged stacker-reclaimer setups with new-generation models, and quicker, more accurate stockpile accounting. Some mines with particular processing requirements have adopted or are in the process of evaluating bulk ore-sorting technology to pre-concentrate low-grade ore from stockpiles, upgrading it to a level that makes economic sense for milling.

A sample of recent industry announcements underscores the degree of interest in stockyard upgrades. In Western Australia, Rio Tinto Iron Ore is moving ahead on a $39 million project to replace stackers at its Paraburdoo mine. The existing stackers were part of the mine's original infrastructure, loading the very first shipment of iron ore from the mine in 1972. In 46 years of operation, they have stacked more than 800 million tons of ore.

TAKRAF is leading the design and implementation phases of the stacker replacement. The company's office in Perth is managing the project, with support from its office in Brisbane and global competence centers. The company said design of the new equipment is under way and fabrication is scheduled to begin later this year, with installation and commissioning finished in early 2020.

The new stackers feature state-of-the-art engineering design and mechanical technology, the latest generation of variable-speed drive control and fiber optic networking, an advanced anti-collision system with GPS backup, and automated operation monitored from the Rio Tinto Operations Center in Perth.

In a similar project, thyssenkrupp just announced it is supplying large-scale stockyard machines for BHP's South Flank iron ore project in the central Pilbara region of Western Australia. The contract is valued at approximately $170 million, making it one of the largest fabrication and construction projects the company has conducted in Western Australia.

The South Flank project is targeting first ore extraction in 2021. Generating roughly 80 million metric tons per year (mt/y) of output, it will replace production from the Yandi mine, which is reaching the end of its economic life. Thyssenkrupp will provide two stockyard stackers and a reclaimer for loading ore trains bound for Port Hedland. The machines will have a capacity of 20,000 mt/h, making them the largest rail-mounted stackers and reclaimer in the world, according to the company, which also noted they comply with the latest Australian design-standard requirements and include technology improvements centered on safe construction, operation and maintenance activities.

Stacking It Safely

At the Roy Hill iron ore mine, also located in Western Australia's Pilbara region, guidance and control specialist RCT reported it played a major role in implanting the mine's dynamic multiple Geofence package, which is interfaced to fixed and mobile asset elements within the boundaries of the Coarse Ore Stockpile (COS). The Geofence technology was interfaced with two D11T Cat dozers and the radial stacker infrastructure, including the boom that can maneuver in multiple directions.

Both dozers were equipped with RCT's ControlMaster Teleremote solutions, which enables the operators to control the machines from a remote station. Cameras are installed on the dozers, along with other cameras on the COS stacker, tertiary crusher infrastructure, and two mobile communications trailers to give operators greater spatial awareness during operation.

The virtual perimeter around the dozers' stockpile area is designed to safeguard operators, ensuring that multiple machines can seamlessly operate in the same area without risk of collision with the fixed stacker infrastructure, or the dozers falling into vaults or driving off the stockpile boundary. RCT said interfacing of the dynamic elements on the site was achieved in partnership with Collision Detection technology from Sitech, Trimble's global site-solutions dealership network.

According to RCT, a number of factors had to be addressed for the Geofence to work effectively. Multiple workshops and risk assessments were conducted to define the Geofence boundaries or virtual perimeters within each element, including the dozers, stacker boom and five vaults. Boundaries were designed to be configurable with proper access authorization, allowing flexibility for the operators.

Sitech's SiTrack software was designed to provide the Geofence boundaries, monitor all interactions and provide alerts within the boundaries, allowing the RCT system's semiautonomous control over the two dozers. This was achieved by using High Precision (HP) GNSS equipment to measure and detect the proximity of the moving assets in the potentially hazardous stockpile to an absolute accuracy of around the +/-25-mm range.

RCT's Custom group worked with Sitech and Roy Hill to develop and deploy the dynamic Geofence system to interface with the ControlMaster Teleremote solutions to ensure machine functionality is inhibited by the ControlMaster system at different levels of detection on the SiTRACK system. The integration resulted in the creation of a variety of configurable Geofence boundaries within the site. Each boundary has different zones to alert dozer operators of potential danger.

With such a high volume of visual data being delivered to the operators from numerous cameras, along with the dozer pitch/roll machine dashboard information and the Trimble tablet display, Roy Hill decided bigger control-room screens were required. The operator station was upgraded from the original two 24-inch (in.) screens and a 17-in. Trimble tablet to two 40-in. curved screens and a 32-in. display for the Trimble screen. A Trimble tablet was also relocated to the side of the operator chair.

According to the project partners, conducting dozer functions via remote control from the operating stations eliminates the risks operators are exposed to at the COS and processing plant, reduces operator fatigue and increases productivity. RCT's Teleremote solution allows for multiple views from the dozer, which increases operator efficiency while helping to minimize machine damage and overall general wear and tear. Downtime associated with shift changes also is reduced, boosting productivity even more.

Taking It Indoors

Environmental considerations are increasingly influencing stockpile design and construction. For example, Siemens announced it is supplying an autonomous stockyard management system to be used in a new plant for HBIS Laoting Steel Co. Ltd., a subsidiary of China's HBIS Group, one of the world's biggest iron and steel producers. The stockyard management system comprises a material tracking and management system (MAQ), an autonomous stockyard operating system (MOM), a Simatic PCS 7 process control system, consulting, engineering, project management and commissioning.

Recent environmental regulations instituted by the Chinese government prompted HBIS Laoting to look at using an autonomous stockyard management system, according to Siemens. The latest regulations require all newly constructed stockyards to be enclosed. The consequent high temperatures and dust levels present in these facilities create hazardous conditions for human workers, and autonomous storage and retrieval machinery is necessary for this type of environment.

The installation, said Siemens, will allow all machines and conveyors to be controlled from a single system. This is achieved using a 3D model of the existing inventory, which provides information on the volume and quality of stocked material, enabling autonomous operation of all the plant's storage and retrieval machines. Siemens claims the system will enable HBIS Laoting Steel to not only reduce its operating costs, but also to achieve a 5%-10% improvement in system efficiency, along with 3-7% higher production capacity and improved worker and asset safety.

Geometrica, a Texas, USA-based supplier of domes and space-frame structures, has built a number of freeform and dome bulk storage structures providing dust control and protection from the elements for mining companies in 35 countries. Some of the benefits that accrue from using their structures, according to the company, include the ability to be erected by local crews without welding requirements or heavy equipment, suitability for location on slopes or irregular terrain, no requirement for interrupting production during construction, and various design capabilities such as resistance to high loads on the structure apex or encapsulation of the discharge point. Geometrica said its structures' foundations can be fitted to the terrain and can accommodate changes in elevation of more than 140 m. Domes can be designed to withstand wind speeds of up to 150 k/h and an ice load of 110 kg/m^2.

Sorting It Out

Australian producer Northern Minerals reported recently it is evaluating the use of ore sorting on five stockpiles at its Browns Range rare earths project in Western Australia to improve beneficiation and feed to the processing facility, which, it said, will result in an increase in the amount of rare earth oxides that can be produced by a recently commissioned pilot plant.

Northern Minerals' Managing Director and CEO George Bauk said the ore sorting technology has demonstrated the potential for the mine to double the mill feed grade, and the company believes the estimated A$4 million up-front capital cost of installing ore sorting technology ahead of the existing Brown Range Pilot Plant circuit is

justified in light of the head-grade improvement demonstrated in testwork to date, along with the anticipated economic benefits delivered by greater production output.

The company said approximately 80% of the value of stockpiled sortable fractions can be recovered in 20% of the mass, representing a four-times upgrade factor; or, alternatively, 90% of value can be recovered in 40% of the mass, representing a 2.25-times upgrade factor. It plans to install an ore sorting circuit in the existing pilot plant, directly between the crushed ore stockpile and the mill feed hopper. The circuit will divert the feed from the primary crusher ore stockpile conveyor over a screen and through the ore sorting circuit that establishes mill feed stockpiles of upgraded sorted ore, a separate fines stockpile, and optionally a blend stockpile of fines and upgraded sorted ore. Rejected, low grade ore is conveyed to the stockpile for processing at a later stage.

However, not all stockpile improvements hinge on high-tech assistance. For example, Teck's Red Dog zinc-lead mine in northwestern Alaska employs a detailed stockpile construction recipe aimed at blending ore to ensure a consistent concentrate quality, based on historical experience gained through building blended piles from Red Dog's Main Pit deposit. That experience enables the mine to create a workable standard to optimize its rich and variable zinc grades.

At Red Dog, optimizing mill feed currently requires blending weathered, baritic and siliceous ore types from two deposits into stockpiles that meet mill requirements. Ore cuts are run against the models, then ordered and sequenced to meet predetermined stockpile criteria. Cuts are organized into roughly 190,000-mt stockpiles that are built in seven lifts on the crusher pad. The stockpiles are designed so the lifts, when mined in strips across the face, create a relatively consistent feed grade profile. The blending process is fine-tuned even further by the dumping sequence. The mine dumps the coarser, often higher-grade ore on odd-numbered lifts, as it has a higher angle of repose in truck-dumped piles. The finer, more variable sized rock (typically lower grade, baritic ores) is positioned on the even-numbered dozed lifts. This blending concept is adjusted as production blasthole assays and pit progression drives stockpile planning.

Piecing It Together

Digitalization's potential for improving overall operational decision-making and risk reduction has drawn stockpile management into a select group of functions that constitute a foundation for future productivity improvements. Skage Hem, vice president, R&D, at FLSmidth, recently explained how the pieces fit together: Noting how digitalization has the ability to "disrupt conventional mining practices in a positive manner, in the last decade, data analytics has become increasingly important in order to optimize processes," he said. "Advances in connectivity, software usability and capacity to store large amounts of data have created a range of potential applications for digitalization, all driving productivity.

"An example of one of these productivity potentials lies in the interplay between the quality variation of the ore and the wear state of the equipment. By understanding how these parameters tie in to process performance, energy consumption and wear rates, it is possible to optimize all or some of these variables. Once data is available, it opens up for different types of maintenance schemes and operational strategies. Combining these with selective

mining, stockpile management and sorting of ore, we will realize significant increases in productivity," he concluded.

Producers interested in exploiting digital opportunities for improved stockpile management can choose from a dozen or so comprehensive mine scheduling software solutions from major vendors — Hexagon, Deswick, RPMGlobal, Datamine, to name just a few — that include either integral or optional stockpile modules; or more-specialized software packages and services that focus on ore tracking and blending, such as solutions from equipment manufacturers Metso (GeoMetso) or FLSmidth (QCX/BlendExpert–Pile). More generalized decision-support software also can be used to solve stockpile-related problems. Australia-based software developer Optika Solutions recently provided an example.

Optika was engaged by a large mining company to essentially answer two basic ore blending questions while the company's process flowsheet was still in its design phase: How to achieve the best approach to blending, and will the selected blending recipe allow the company to meet its production targets? Of main interest was the potential benefit of establishing a coarse ore stockpile.

According to Optika, its Akumen analytics platform proved to be the right tool for this problem through its inbuilt scenario management and execution features. Akumen's Asset Library was used as a single source of truth for all asset-related data, helping to identify and resolve conflicts in process configurations.

Based on the final overall model developed by the platform, it was shown that a coarse ore stockpile between crushing and the plant would be beneficial from several aspects such as keeping the grade of the plant feed within the target range more than 95% of the time and enabling the mine to meet operational targets on throughput and utilization, since it decouples crushing and ore processing.

Speeding It Up

Effective stockpile management depends on accurate, timely updates of pile volume and content. Accuracy and speed of completion are necessary to make volume surveys useful, and until recently these two criteria were often mutually exclusive or extremely cash- and resource-intensive. However, the emergence of stockpile evaluation using sensor-equipped UAVs, mobile and stationary LiDAR equipment, satellite photogrammetry and even smartphone apps has mostly eliminated the traditional practice of assigning a survey crew to walk the site and climb stockpiles in order to measure them — thus reducing the obvious risk factor, dramatically speeding up data collection and analysis, and avoiding the occasional need to shut down operations while crews were taking measurements.

The latest generation of sensor-equipped UAVs, for example, can provide single-digit centimeter-scale survey accuracy, while the convenience and low cost of drone operation allows producers to conduct stockpile surveys far more frequently and eliminate outside-party involvement in collection and analysis of what might be considered sensitive information. The availability of drones suitable for industrial use and the rising interest from industrial customers in drone surveying and inspection has spawned a large number of UAV-related enterprises catering to resource and infrastructure industry customers. How many of these fledgling companies will survive the rough air of the turbulent UAV services marketplace remains

An RTK module is integrated directly into DJI's new Phantom 4 RTK drone, providing real-time, centimeter-level positioning data for improved absolute accuracy on image metadata. The drone's new TimeSync feature continually aligns the flight controller, camera and RTK module.

to be seen, but even major OEMs like Hitachi, Komatsu and Caterpillar are spending money to establish a foothold in the sector, implementing drone-based hardware, software and services to add another dimension to their connected-worksite scenarios Dominant players in the sector continue to offer and expand a variety of solutions that include drone models designed for professional and "prosumer" users, tailored drone mapping and surveying software packages, and even fully automated drone operation, service and data analysis.

Among the most recent developments, Propeller Aero, a cloud-based drone analytics company, is partnering with drone builder DJI to create the Propeller PPK Solution based on DJI's new Phantom 4 RTK drone. Propeller also announced the startup of a partnership with Komatsu America in August, starting with a focus on construction-site management, but with the mining industry in mind as well.

Propeller said its PPK Solution is a fully integrated software and hardware system that reliably provides photogrammetric model outputs in geodetic, projected or local coordinate systems. It provides accuracy of 3 cm from independent checkpoints across small and large survey areas (checkpoints up to 1 km from GCPs). To capture surveys of this accuracy, all that is needed is one "smart" control point on the ground, over a known point if working in local coordinates. Propeller claims its PPK Solution has been shown to reduce the time required to complete a drone survey by 70% compared with a traditional workflow using multiple GCPs across a worksite.

DJI launched the Phantom 4 RTK quadcopter in mid-October, featuring an RTK module integrated directly into the drone, providing real-time, centimeter-level positioning data for improved absolute accuracy on image metadata. Non-RTK drones require multiple ground control points per square kilometer, which take several hours to place. The DJI Phantom 4 RTK has a centimeter-accurate RTK navigation positioning system and a high-performance imaging system, and potentially reduces the number of GCPs needed to zero. Sitting just beneath the RTK receiver on the drone is a redundant GNSS module to maintain flight stability in signal-poor areas.

DJI said the RTK module can provide positioning accuracy of 1 cm+1 ppm (horizontal), 1.5 cm+1 ppm (vertical), and the Phantom 4 RTK can produce the 5-cm absolute horizontal accuracy of photogrammetric models.

In late October, Kespry, another drone-based solution provider, and DJI announced they also are partnering to offer the DJI Mavic 2 Pro drone as part of Kespry's stockpile measurement solution for mining companies. The company claims adding this solution will enable miners to standardize and capture stockpile data across all their sites in the Kespry platform, while continuing to use the Kespry 2 drone platform to support mine and site planning operations.

George Mathew, Kespry's CEO and chairman, said, "Our goal with the addition of the Mavic 2 Pro to our solution is to respond to our customers wishing to use the Kespry aerial intelligence platform across all mine sites to standardize how stockpile data is generated."

Companies that choose to conduct their drone operations in-house can benefit from the advantages offered by this type of setup, but they also face the effort and expense of training personnel, staying current on drone technology and regulations, and maintaining the equipment. For producers interested in adopting drone-based activities but don't want the attendant hassles of in-house operation, Airobotics offers what may be an attractive solution — a fully automated, industrial level, multipurpose drone platform comprising a high-capacity drone, an automated base station and cloud-based software. The system doesn't require a pilot for operation.

The drone automatically launches from a freestanding base station (Airbase), and flies pre-programmed or on-demand missions to collect aerial data. Once a mission is complete, the drone returns to the Airbase, where a robotic arm replaces its battery and payload before deploying the next mission.

Airobotics' fully automated drone system stores and services the drone in a self-contained enclosure called the Airbase. A human pilot or attendant is not required to conduct flight missions.

Israel-based Airobotics said the system is currently being used by several mining companies, including ICL, South32's Worsley Alumina operations in Western Australia, and the Minera Centinela copper mine, owned 70% by Antofagasta Minerals and 30% by Marubeni Corp., in northern Chile.

Airobotics' drone software, according to the company, is both a complete operating system and an open platform. Third parties can build and customize the payloads, along with software apps to support and manage new types of missions. The company uses SimActive's Correlator 3D suite for photogrammetry-based volume calculations.