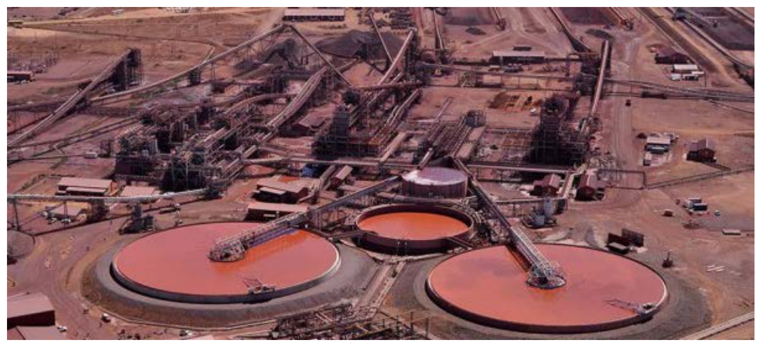
Case Study: Paste thickening optimises tailings disposal and water recovery at iron ore mine

July 30, 2015 Features Robyn Schmitt

Disposal of mine tailings, and their impact on water usage and environmental issues, is one of the most important concerns for any mine during its lifecycle.



The challenge today in the management of tailings, whether they be aluminum, zinc, gold or iron ore, is how to dispose of tailings material such that it is contained and stable, while maximising water reuse and minimising surface footprint.

While significant pressure is placed on mining projects in well-developed countries, such as the United States and Canada, to conform to stringent water conservation and environmental standards in their disposal of tailings, an increasing number of nations are instituting significant steps to require water reuse and mitigate environmental damage.

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In Chile, for example, where desalinisation plants along its coast are needed to provide water for that country's vibrant mining operations, the need for water reuse management is critical, prompting mining operations to explore the most efficient options for water reclamation in tailings disposal.

In Peru, which has a huge mining sector, and similarly in Brazil, stiffer environmental regulations are being put into place for mining operations, largely because of the environmental impact concerns on native populations.

Mines throughout the world face challenges as their tailings dams are nearing capacity, or are unstable and raise the potential for dam failure, both conditions that would require heavy capital investment to rectify.

Yet, many of these mines could minimize or delay this liability by reducing the volume of water put into their tailings disposal facilities, which would improve capacity and stability, while reclaiming more water for reuse in their upstream washing, screening and jigging processes which require high water usage.

Water reuse in mining tailings disposal becomes particularly critical in arid and semi-arid environments where water availability is limited and usage is closely regulated by government mandates, such as in the semi-arid climate of South Africa.

One iron ore mining operation that has successfully adapted its tailings disposal and water reuse procedures to this environment is Khumani Iron Ore Mine.

Khumani Iron Ore Mine – Focus on Water Recovery

South Africa's Khumani Iron Ore Mine (Khumani) is situated in Northern Cape Province. The iron ore deposits are located approximately 60 km north of the Beeshoek mine on the Bruce, King and Mokaning (BKM) farms, adjacent to Kumba's Sishen Iron Ore Mine.

The Khumani mine is part of Assmang Limited, which is jointly owned and controlled by African Rainbow Minerals Limited and Assore Limited.

Beginning operation in 2008, Khumani is a large iron ore mine, producing on the order of 16 million tons of product annually.

After primary and secondary crushing, the processing of Khumani's iron ore involves wet washing and screening, jigging and fines recovery through the use of de-grit cyclones. Because each of these processes requires large volumes of water, from the initial design stage it was evident that water recovery would need to play an integral part for the mine to be successful.

"This area is a semi-arid climate, yet it supports a number of large mining operations, and an ever-growing local population and assorted infrastructure, so there is a limited quantity of water available for distribution by the Sedibeng Water Management Board," Thomas Du Toit, the metallurgical manager for Assmang Iron Ore, said.

"This created a number of challenges for the Khumani mine, as our preferred process involved wet processing, but we did not have the available water.

"We also had to contend with high evaporation rates, and the lack of suitable sites for a conventional tailings facility," he said.

"We needed to design a system that could recover most of the water, and not lose a large percentage to evaporation."

To maximise its water reuse capability, the Khumani plant contracted WesTech Engineering, which designed and implemented a two-stage tailings thickening process.

The first stage consists of two primary high-rate traction slurry thickeners, each 90 metres in diameter, situated at the main plant.

The first thickener was installed in 2008, with the opening of the mine. The second thickener was added in 2012 to accommodate a 100 per cent increase in the plant’s production line and throughput capacity.

The two high-rate thickeners operate as clarifiers, returning the bulk of the clarified water to the main plant at the combined hydraulic flow rate of 14,866 to 17,981 cubic metres per hour. These thickeners recover approximately 90 per cent of the slurry water by volume.

Most mining facilities would then deposit the tailings slurry direct into a tailings pond at approximately 40 – 50 per cent solids.

But this type of high-rate primary thickener was inadequate to produce the slurry densities required for the desired water reclamation. An additional thickening and disposal option needed to be implemented to maximise water recovery.

Secondary Stage – Paste Thickening

WesTech engineered a solution utilising paste thickening technology to facilitate the second-stage tailings thickening process.

The dilute slurry from the primary high-rate thickeners is pumped a distance of approximately 4.8 kilometres– to an area with adequate storage capacity for the expected 25-year life of the mine – to feed two 18 metres diameter paste thickeners at the plant’s paste disposal facility (PDF). The first of these paste thickeners was put into place when the original plant was built in 2008, and the second installed in 2012 to accommodate the mine’s increased capacity.

"The size of the two secondary paste thickeners was determined from the residence time required for the slurry to reach terminal solids concentration," Philip Lake, WesTech’s International's business unit leader explained.

"Each of the two secondary paste thickener systems accommodates feed tonnages varying from a minimal 133 tonnes per hour to 272 tonnes per hour. Volumes up to 408 tonnes per hour can be buffered in each of the secondary paste thickeners for short periods of time.

"The paste thickeners recover at least 75 – 80 per cent of the water by volume from the primary thickeners, increasing total water reclamation in excess of 95 per cent. These rates ensure adequate capacity in the thickeners to achieve high-density paste.”

"The paste disposal facility requires a minimal solids concentration of approximately 58 to 60 per cent by mass, in general," Lake said.

This is due in part to enable pumping of the thickened slurry to the outer limits of the dam wall using centrifugal pumps, but also to allow the material to be deposited in layers of less than 10 centimetres to ensure effective drying and consolidation.

The PDF was three-dimensionally modelled for an accurate determination of the relationship between the height, area and capacity.

The detail was processed to calculate the rates of rise for average production rates and eventually the life of the PDF. It has been designed as an impoundment (compacted earth embankments) into which the tailings stream is deposited.

The construction is phased, with the facility built to accommodate tonnage expansions.

Paste, or thickened tailings, has become an increasingly important method to address many of the environmental problems facing the mining industry.

Pasting was originally developed by the alumina industry in the 1970s, and for the past 20 years has been applied worldwide in other mining applications.

Yet today, less than 1 per cent of iron ore mines employ systems for paste thickening, despite the benefits it can provide for optimisation of tailings disposal.

"Khumani's secondary paste thickening process delivers substantial benefits," Lake stated.

"Not only does it recover water, which can be reused in the plant, but it also leaves less water in the deposit site. In a paste disposal, because of the nature of paste tailings, the particles within it are well distributed. The coarse particles (200+ microns in size) are uniformly intermixed with the finer material (less than 20 microns).

"Therefore, in the non-segregating deposit, this homogeneous particle distribution facilitates water to be pulled up to the surface by capillary suction where it can be evaporated. In addition, the beach angle of the deposition forces free water to accumulate at the low point of the PDF to be collected and reused by the plant.

"The process is quite different, however, in a conventional slurry tailings dam," he said.

"The slurry segregates into coarse material that settles out first at the deposition point, and the ultra-fines are carried further into the tailings facility. Because the ultra-fines have segregated from the coarse material, they do not tend to settle over time, and the free water on the tailings pond cannot be reclaimed for reuse, as is.

"The result is a long-term wet deposition with liquid fractions inside the tailings pond, which if breached can result in dam failure. A condition that is unlikely to occur with paste deposition where the balanced distribution of the course and fine particles, coupled with the reduced water content, provide more compact space utilisation and much better structural integrity within the tailings dam."

An additional environmental benefit of paste tailings is that the paste tails tend to dry and form a hard crust, as opposed to the conventional tailings that have a very fine powder deposition of ultra-fine material which will likely create dust pollution.

Studies indicate that thickened paste tailings can provide up to a 40 per cent reduction in tailings dam construction, both in material quantities and capital costs, and allow more flexible options for dam locations, compared to conventional slurry systems.

Unique Installation

The Khumani project has demonstrated that it is possible to successfully build and operate a wet processing iron ore mining operation in an arid environment where water supplies are limited, providing an integrated design philosophy and sound engineering practices are in place.

"The two-stage water recovery and paste disposal system that has been successfully implemented at Khumani iron ore mine is a unique installation, by any standard," Du Toit said.

"The combined use of primary and secondary thickeners in iron ore mining has rarely been implemented. Particularly with the integration a very large-sized 295-foot diameter primary thickener, linked to a secondary paste thickener located three miles away at the paste disposal facility.

"This system provides long-term environmental and cost efficiencies that few, if any other iron ore mining facility, can realise."