Decanter centrifuges:
Making dry stack tailings storage more efficient

by Robert Klug and Nils Engelke

In order to extract proportionately small quantities of valuable minerals, mining companies move large amounts of earth. A resulting waste product of this process has traditionally been stored in a semi-liquid phase known as tailings, typically stored in a large pond created by an earthen dam at the low end of a drainage basin. It is generally expected that these dams are stable enough to withstand the pressure of the stored material. Unfortunately, history shows us that this is not always the case. The Baia Mare dam in Romania failed in 2000, causing tragic and prolonged environmental damage to several major European rivers. The Bento Rodrigues dam in Brazil failed on Nov. 5, 2015, and that event resulted in the loss of 16 lives.

In hard rock mining, many minerals are imbedded within the ore. As part of the mining process, valuable minerals are extracted from the ore; often, the mineral content is only a fraction of the total ore volume processed. To extract the minerals, the ore is typically crushed and pulverized into very fine particles, then wetted to form slurries. The minerals are extracted from the slurries through a series of flotation and/or sedimentation steps with the aid of water-soluble separation chemicals typically known as reagents. Following the mineral extraction, the resulting residual wetted ore cuttings are labeled as tailings. At the end of the extraction process, the tailings are in a thick semi-fluid sludge state, often with trace elements of the extraction reagents.

Historically, these tailings are deposited in giant basins or sludge ponds, where they pose a great threat to the environment while binding large volumes of waste process water.

Process water recovery and achieving dry tailings

Current generation engineering studies, trials and successful field implementation have shown that an alternate process known as dry stacking is practical. The dry stacking process deposits dewatered tailings into containment areas that are smaller in overall footprint and significantly safer by reducing the transfer of reagents into the tailings storage area. In addition to achieving the dry tailing benefits mentioned, it is possible to recover valuable process water while dewatering the tailings sludge utilizing modern separation technology.

Flottweg decanter during a test run in South America.

With environmental stability being seen as a key factor in modern mining, this method of dry stacking tailings is becoming increasingly popular. Dry stacking can eliminate nagging concerns related to potential dam failures in known zones of high seismic activity. Globally, many places are challenged because sufficient amounts of fresh water are not available in the mining regions; the dewatering process can capture as much as 90 percent of the water for reuse.

Dry tailings

Dry tailings are typically achieved through a multi-step process. The sludge is thickened or concentrated through gravity settling in a thickener. The thickener is a conical bottom vessel equipped with scraper paddles that move thickened material to a discharge opening at the bottom center of the cone. The concentrated sludge is withdrawn from the bottom and clarified water exits the top of the thickener via weirs. The thickened sludge is then processed through one of several types of mechanical dewatering machines to achieve dry tailings for stacking.

Three devices proven to have various degrees of success with dewatering the thickened sludge are: belt presses; plate and frame chamber filter presses

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Figure 1

Space and weight matrix.

	Belt Filter Press	Chamber Filter Press	Decanter
Installation	🪙🪙🪙	🪙🪙🪙🪙🪙🪙	🪙
Space	↔↔	↔↔↔	↔
Maintenance	🔧🔧🔧	🔧🔧🔧🔧	🔧
Solid Disposal	🪙🪙🪙	🪙🪙	🪙
Ventilation	❋❋❋❋	❋❋	❋
Water	💧💧💧💧💧💧💧💧	💧💧💧💧	💧
Labor	⚙⚙	⚙⚙⚙⚙	⚙
Power	⚡	⚡	⚡

and decanter centrifuges. Due to an ability to provide a consistently high dry solids output and continuous feed process, the centrifuge has been gaining in popularity in recent years.

The belt press. The belt press provides a continuous feed operation, with slightly wetter end product than other dewatering processes. Concentrated sludge treated with polymeric flocculants is evenly spread over a narrow-pore belt. The sludge on the belt is exposed to a vacuum from below in order to remove the liquid from the sludge. The belt moves forward and delivers cake to one end of the machine, where it is deposited into a collection container. While the belt returns to the starting position, it is washed several times with clean water to reopen the porous fabric in preparation for the next process cycle. The filter bed is a large area open to the surrounding environment. Containment sumps and drainage systems are required to contain the wash water and the extracted filter water.

The chamber filter press. The filter press is a batch process for the solid-liquid separation of suspensions; it provides a higher dry solids output than belt press and discharges in cycles. The package consists of filter plates in a frame arranged between a fixed and a movable end cap. Filter media (fabric or membrane) is located between the individual filter plates. The fixed end cap is connected to the bridge by connection and traction bar. The chambers are filled with concentrated sludge treated with polymeric flocculants until baseline pressure stops the fill process. Then the filter package is pressed via a hydraulic pressing device pushing the movable end cap toward the fixed end cap. The compression cycle applies process pressures between 3,000 and 8,500 psi on the filter plates. The density of the dewatered product is proportional to the pressure applied. The liquid passes through the filter media and leaves the press via drainage channels. The solid particles of the suspension remain in the filter media and form the filter cake. After the compression cycle is complete, the press is opened and the cake is removed. The pressure is slowly released, the filter press is opened, and the cake is removed from the filter cloths. Some presses provide shakers to automatically assist with cake removal, but often that automation is augmented with manual labor to completely remove the dry tailings before a new cycle can start. The filter cloths must be cleaned with washing liquid regularly, since they can clog over time. This is a labor-intensive batch process.

The decanter centrifuge. The centrifuge provides a continuous product discharge with a high dry content and the unique ability to make on-the-fly adjustments to maximize discharge material dryness. The decanter employs centrifugal acceleration, accelerating gravity between several hundred to several thousand times, to rapidly separate a liquid and a solid phase.

The solid particles (of higher density) are pushed to the outer bowl wall and transported to the discharge openings by an internal screw conveyor. At the same time, the clarified liquid accumulates in the center of the machine and exits through the liquid discharge zone. Water recovered in the centrifugation process is usually greater than 98 percent clear. The decanter is a fully automated and closed system. Large quantities of product can be processed and multiple adjustment variables can be set to provide the desired end product.

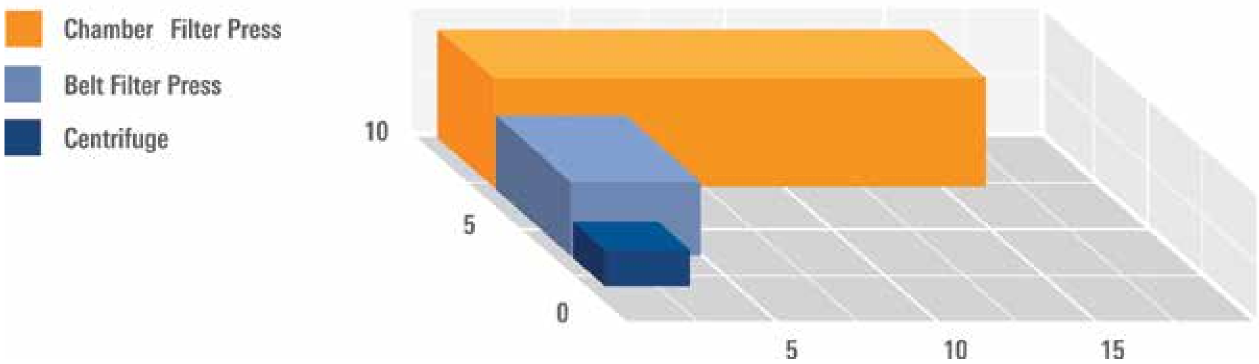
Special wear protection advances tested and proven in recent years have made specially fitted centrifuges less susceptible to wear, supporting extended lifecycles. For example, decanters from Flottweg guarantee low maintenance costs and very limited downtimes.

The matrix in Fig. 1 illustrates the differences among the systems. Within the matrix, variables for each type of machine are referenced.

Space and weight requirements. Mining

Figure 2

Individual unit weights.



operations are frequently located in remote places that are difficult to access and where space savings can be very advantageous. The Fig. 2 graphic displays the physical space requirements for each of the three different mechanical dewatering systems discussed herein. The reference provides a representation of machines with capacities of 18 t/h (20 stph).

Additionally, the weights of the individual units may play a crucial role in the purchase decision.

- Chamber filter press 108 t (120 st)
- Belt press 59 t (65 st)
- Centrifuge 14.5 t (16 st)

Dewatering capacities. The product dryness from the chamber filter press and the centrifuge are roughly the same. A belt press rarely achieves equal dryness. The centrifuge separates all particles larger than 5 micrometers without flocculants. Polymeric flocculants are utilized to separate smaller particles. These must be used with the chamber filter press (and the belt press), regardless of particle size. Deposits build in the filter cloths (chamber filter press) and in the filter belt (belt press) after some time. This means that the draining capacity is reduced and the system has to be cleaned. The centrifuge is also the only dewatering system proven to provide a consistent process at high dry solids levels.

Case study at a remote mining facility. The Tiebaghi nickel mine in New Caledonia is located in mountainous terrain with very little water. These conditions, as well as the fragile ecosystem in the region, led to the mine operators placing a high value on the recovery of process water.

The first contact between Flottweg, a separation technology specialist from Germany, and the operators of the mine occurred in 2006. At that time, the mine had consumed 650,000 m^3 (171 million gal) of fresh water per year. So, the challenge was to recycle the water so it could immediately be reused.

After extensive testing and comparing the different dewatering units, the mine operator (Eramet) decided to purchase decanter centrifuges from Flottweg. Flottweg installed eight Model Z92-4 decanters. The Z92 model is one of the largest decanter centrifuges in the world, with a bowl diameter of 920 mm (36 in.). Each machine processes a throughput volume of 130 m^3/h (34,000 gal/hour). The treated tailing sludge contains roughly 10 percent solids by weight.

With 98 percent of the process water recovered, the mine operator was naturally excited about the results.

In addition, the operating company was able to reduce its dependence on costly dams — and the associated risk of a dam failure that could jeopardize the environment.

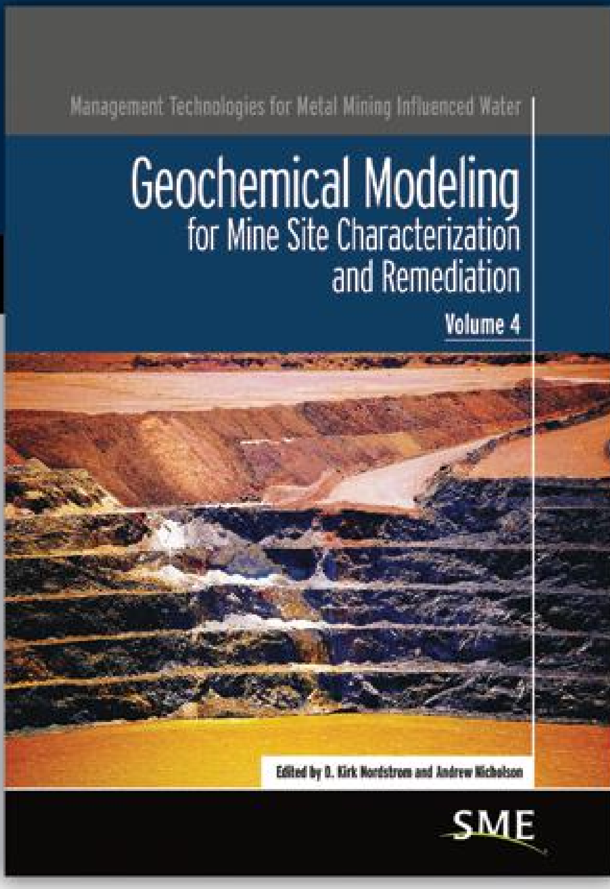
Summary

Dry stacking of dewatered tailings can eliminate future tailings dams and dam failures, significantly reducing the risk to the environment and people.

The use of centrifuges is an excellent means to continuously dewater waste slurries to achieve dry tailings. Recovered process water can be returned to the process within a very short period of time. The need to supply fresh water can be reduced.

Centrifuges require less fresh water, less manual labor intervention and less maintenance for dewatering. They are also significantly smaller, which makes it easier to use them in difficult-to-access areas. Because the centrifuge is a completely closed machine package and process, they do not require an indoor facility when located in non-freezing environments.

The results from New Caledonia and other projects have demonstrated that the process of dewatering tailings can be useful and cost-effective when the proper dewatering system — i.e., a centrifuge — is selected. ■



Geochemical Modeling
for Mine Site Characterization and Remediation

Edited by D. Kirk Nordstrom and Andrew Nicholson

The single most important factor for the successful application of a geochemical model is the knowledge and experience of the individual(s) conducting the modeling.

Geochemical Modeling for Mine Site Characterization and Remediation is the fourth of six volumes in the Management Technologies for Metal Mining Influenced Water series about technologies for management of metal mine and metallurgical process drainage.

This handbook describes the important components of hydrogeochemical modeling for mine environments, primarily those mines where sulfide minerals are present—metal mines and coal mines.

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