Improving the performance of Mineral Flotation by treating Process Water

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Abstract

The drive to recycle process water has obvious benefits regarding a lower water footprint. However, for some mines, especially those where more than one mineral is simultaneously mined, recycled process water can have a negative effect on mineral recovery by flotation, with a significant economic impact on the operation.

Typically, fresh or makeup water has a low dissolved solids content and does not negatively affect flotation and mineral recovery. However, as the water is recycled, it picks up dissolved solids by leaching the ore, and at some point the level of dissolved solids may begin to affect recovery. A significant amount of work is being done to identify which species are most detrimental to mineral recovery, how to treat and reduce those species, and how to devise test procedures and models to simulate the interactions of species. We present here some preliminary results showing how water quality affects flotation and examples of improvement in recovery by changing they type of water used in flotation experiments.

Introduction

Mining requires a steady supply of water resources. However, the availability of Water is becoming a significant issue for many Mineral Processing operations, with the following major trends influencing the use and recycling of water:

- Mineral ore grade is decreasing, which means that more ore must be processed, and more water must be used to produce the same amount of metal as before.

- Underground and some surface water resources are becoming scarcer, so less fresh water is available for making up water lost in the Mineral Processing operation. These losses are mainly from moisture contained in the mineral concentrate leaving the site and water lost as evaporation. In addition, water is also immobilized with tailings.
- Pressure is increasing for water resources to be used more efficiently to comply with Corporate Environmental and Social Responsibility.

These trends result in a strong drive to increase the recycling of water. To illustrate one way in which this recycling could be achieved, let`s consider the following diagrams, the first one being for a typical temperate zone:

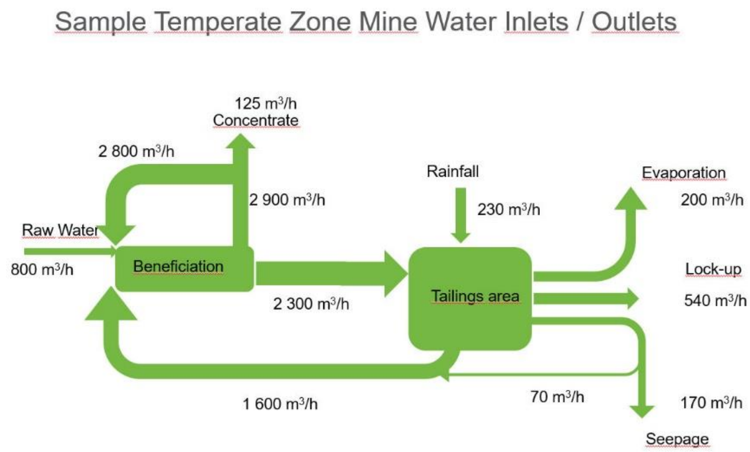

Figure 1: Simple Mine Water Balance for Temperate zone

Some temperate region mines even have water surplus, in which case there are additional issues around effective treatment for water discharge. Now let`s look at the situation for an arid zone, which changes the relative flowrates quite a bit:

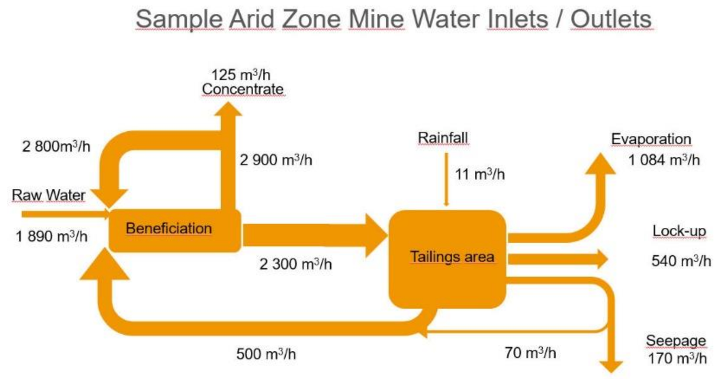

Figure 2: Simple Mine Water Balance for Arid zone

Now evaporation is significantly greater, so raw makeup water is therefore greater as well. If the circulating water loop that goes from the Concentrator to the Tailings Storage Facility and back is closed, by filtering the tailings and therefore making more water available for recycling, we would have the following:

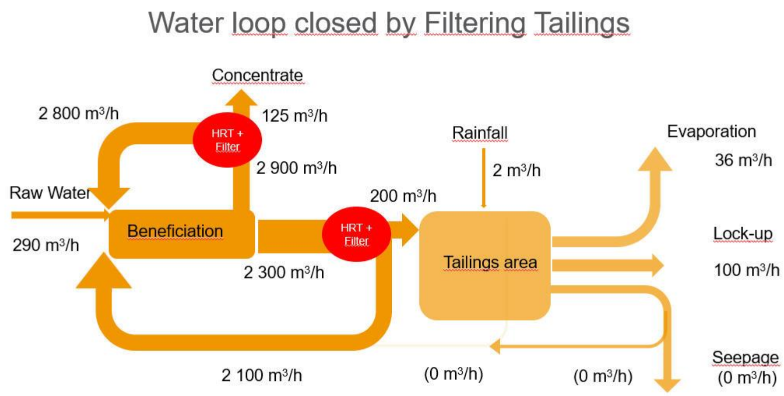

Figure 3: Closing Water Loop by Filtering Tailings

Closing the water loop allows for a more efficient use of water with less makeup water needed, and also for a much-reduced need for space to store tailings, with important savings in Tailings Storage Facility (TSF) construction costs. These savings in water cost and TSF construction must be balanced against the capital cost of a Tailings filter plant and additional power required for the filtration.

This is just one example and water can be recirculated at a mineral processing plant in many different ways, from a simple way in Figure 2, to a more sophisticated way in Figure 3.

Another critical point is that water is in contact with the ore, and depending on the recycling method used, contact with the ore is more or less intense. For example, when Tailings filtration is used, water is recycled more often and comes into contact with fresh ore many times more than with conventional Tailings handling. As the water comes into contact with the ore, it dissolves species from the ore, a process that can take a long time, or be significantly accelerated when using shorter water loops.

When water is recycled with more intensity, it often accumulates dissolved species because there is more contact time with the ore.

This poses an important question – for a Greenfield site, where we often do not know much about the water quality, what will be the composition of process water quality at equilibrium? Work in this area has led to development of a method to assist in predicting the water quality for projects where the water quality is unknown (Le Thi et al, 2020).

Now we turn to the question of how water quality affects flotation recovery (Liu, Musuku, 2016).

For copper sulfides, when water recycled from the effluent of a municipal wastewater plant is used for copper flotation, the organic compounds remaining in the water affect the foam in the flotation cell.

The remaining compounds can cause a loss in the recovery of around 10%. Therefore, the organics must be removed from the municipal wastewater before using it in the copper concentrator plant.

For molybdenite and copper sulfides occurring together, when seawater is used for the flotation process, copper sulfide flotation is acceptable, but molybdenite recovery is decreased significantly by seawater. Therefore, the seawater has to be processed by a reverse osmosis plant to reduce the salinity of the water before using it for molybdenite flotation.

The recovery of copper sulfide on its own is not as sensitive to water quality as other minerals. In particular, nickel pentlandite flotation recovery is very sensitive to changes in water quality. When nickel pentlandite is associated with copper, the sensitivity is increased as shown in recent work (Kasymova et al. 2021).

We now present some preliminary results of changes in flotation recovery from flotation tests performed with clean water and process water.

Methodology

Flotation tests were run using ores sampled from mining partner companies. Ore samples were taken from concentrator feed, so that no grinding was carried out. The samples were adjusted for pH and conditioned with standard flotation reagents. pH and other conditions were held constant while varying only the quality of water used in the flotation runs.

Raw water was taken from the site fresh water supply line, pond water from tailings pond, process water from concentrator thickener overflow, and treated process water was obtained by treating Concentrator Thickener overflow.

Results and Discussion

Table 1 shows preliminary results from Flotation tests where different water sources were used as a Flotation medium for tests on different commercial ores:

Source Water	Case 1 - Cu	Case 2 - Au	Case 3 - Ag	Case 4 - Fe	Case 5 - Li
Raw	80.5 % Rec	53.0 % Rec	67.5 % Rec	-	88.2 % Rec
	17.5 % Grade				3.1 LiO2%
Pond	76.7 % Rec	53.1 % Rec	43.1 % Rec	-	67.3 % Rec
					5.0 LiO2%
Process	78.9 % Rec	73.1 % Rec	62.2 % Rec	85.0 % Rec	59.4 % Rec
	14.0 % Grade			SiO2 4.7%	4.5 LiO2 %
Treated process	85.5 % Rec	78.0 % Rec	69.7 % Rec	87.7 % Rec	78.2 % Rec
	19.2 % Grade			SiO2 1.2%	4.9 LiO2%

Table 1: Preliminary Results from Flotation Tests with Treated Process Water

As mentioned previously, some minerals are more sensitive than others toward changes in water quality. In general, it is seen that using either pond or process water (where we know that total dissolved solids are greater for the reasons explained above) shows a detrimental effect on recovery. In particular, Iron and Copper do not show a very large sensitivity, whereas Lithium, Gold and Silver show important effects.

If we consider other mining processes, water qualities needed for mineral grinding and conveyance are not important. In contrast, it is known that water quality is critical for electrowinning, which typically requires reverse osmosis quality water with conductivity less than 100 microsiemens and low chloride levels.

Methods of pre-treating the water for use in the flotation runs above include reverse osmosis, sulfate precipitation, dissolved air flotation, oxidation of organics, and filtration. Further details will be given in future publications. In conclusion, a simultaneous deep understanding of water chemistry and mineral processing can result in operational savings.

References

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