Higher quality of backfill and a sustainable approach of total tailings management

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THE BIGGER PICTURE

Zlatko Martic and Martijn K. Mannot-Russell, Master Builders Solutions, explore how changes to the dewatering process for tailings can lead to higher quality backfill and savings in cost and carbon.

A sustainable approach to mining considers all the processes involved and the complex interactions between them. The goal is to maximise return on investment and minimise the negative impacts on local communities and the environment.

One area where changes could deliver economic, environmental, and social benefits is the treatment of tailings to transform it into a material with the optimum properties for backfilling. By refining the dewatering process, it is possible to reduce the proportion of tailings that must be stored on the surface and to lower the amount of cement used to stabilise the tailings, thereby reducing aboveground impact and the overall carbon footprint of the operation.

Savings can be significant. For instance, in the following case study a change in the dewatering approach led to a cost saving of €0.30/t, a reduction in cement of 22.2%, and a reduction in water use of 8.7%. The quantity of tailings deposited at the surface fell by 81 000 tpy (Table 1).

There can be broader operational benefits too. A rheologically engineered backfill can be faster and easier to place, causing less wear and tear on equipment.

Table 1. The benefits of a changed dewatering approach

										With ad-mixtures		Without ad-mixtures		
Solids	Binder	Mix design	Mine backfill capacity	Dry tailings (tpy)	Binder mass (tpy)	Binder reduction with ad-mixtures	Water (m^3/y)	Water reduction with ad-mixtures	Total solids mass (tpy)	Water savings (m^3)	More tailings underground (tpy)	Volume of additional slurry to be disposed on surface (m^3/y)	Surface required for 0.5 m thickness	Football field 100 x 70
77%	4.5%	Control	3 000 000	2 206 050	103.95	20.2%	690 000	8.7%	2 310 000	60 000	81 000	46 575	93 150	13.3
79%	3.5%	Admixtures	3 000 000	2 287 050	82.95		630 000		2 370 000					

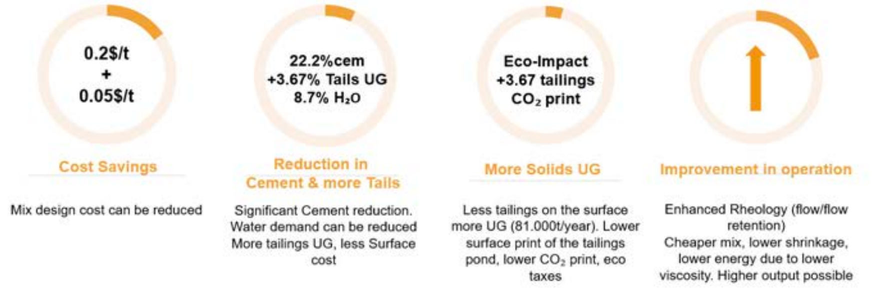

Figure 1. Cost savings and positive impacts.

Figure 2. Without ad-mixture (left), and with MasterRoc MF (right).

Lower water content in the backfill can lead to faster curing times and hence a faster mining cycle.

Dewatering challenges

Inadequate dewatering leads to poor results in the backfilling process; this is a trend observed in multiple mining operations over the years. Problems with dewatering can be due to failures in the thickening system and poor design or changes in the material in the tailings.

Often the retention tank, which stores the tailings before the filtering operations, is designed with insufficient capacity. With a smaller tank there can be a higher fluctuation in the solid content or density of the tailings. Having a larger tank may lead to less fluctuation in the slurry density, stabilising and homogenising the feed before filtering.

The use of unsuitable flocculants or omitting flocculants altogether is sometimes the cause of problems. Alternatively, there may be changes to the material feeding into the process due to changes in operation or changes in the characteristics of the ore itself. Poorly trained staff or insufficient maintenance regimes can also be an issue.

Any of these factors may mean that the output from the thickening and conditioning processes are very different from what was expected. This in turn results in poorer backfill, with a wide variation in properties or a far higher water content than originally designed.

An integrated approach

A holistic approach to mining requires multidisciplinary knowledge from specialists in different fields and professions. Within leading mining companies, collaboration between departments, consultants, and suppliers leads to innovations and optimisation of different aspects of the mining operation.

Dewatering should be considered as an integrated and essential stage in ore and tailings treatment, as part of the entire mining cycle, rather than a standalone activity or process. It is important to consider the impact of the dewatering measures chosen on longer-term issues, such as the closure of the mine in the future, impact on the environment, and social effects. At the same time, decisions should optimise the efficiency of the operation and increase the profit, looking at the total net present value (NPV) with respect to costs at all the stages of project development, including mine closure.

Cost savings though long-term strategy

Focusing on costs over the complete life of mine (LOM), rather than the cost of the dewatering process alone, will change the decision-making process. Additional capital expenditure or higher operational costs can ultimately lead to lower final costs and improved outcomes.

For instance, achieving more consistent tailings properties from dewatering operations may result in a much more reliable mine backfill requiring lower cement content, leading to lower overall mining costs. In practical terms, this equates to more reliable and predictable mechanical properties of the backfill such as uniaxial compressive strength (UCS).

Case study

To better understand the total value of an integrated approach, it is important to evaluate the impacts of change both downstream and upstream. The following example from industry aims to illustrate the benefits to both the mine and wider society of considering total cost rather than single process cost.

A base metal mine produces approximately 5.8 million tpy of ore, with the backfill plant producing 3 million tpy of cemented paste fill. The backfill operation uses fresh tailings from the mineral processing flotation circuit, which are thickened to produce a high-density slurry which is retained in the tank before filtering. Filter cake is transported via a conveyor belt to a paste mixer where cement and process water is added to adjust it to the required consistency.

The backfill operation works by gravity, without the use of a positive displacement pump. The thickening system was designed to operate without flocculants (chemical additives) as it was designed for coarser materials. Additionally, the backfill plant was designed to be used without chemicals. This means that the conditioning tank is of a smaller capacity, designed for a high throughput of thickened tailings, with no consideration of the potential fluctuation in slurry properties as it feeds to the filter.

Over several years, the mine operator made changes to the flotation circuit to optimise the recovery of the valuable minerals, modifying the grinding parameters to produce a finer product. The consequence of these changes to the downstream operation is finer tailings which must be processed for the backfill operation.

As the thickening operation was not designed for fine grained tailings, a higher fluctuation in the system's outputs was observed. The retention tank was not big enough to compensate for the fluctuations in the slurry density, resulting in a high variation in the properties of the feed to the backfill and in the capacity of the plant.

The most significant impacts for the mine of this mismatched process were a high variation in the UCS of the backfill material placed underground, increased consumption of cement, higher costs, and lower profit.

After analysis, suitable flocculants were found which improved the settlement and overcame the capacity issues as well as minimising the fluctuation in density of the feed to the filters. Further improvements were made to optimise the backfill. After a detailed study of the material properties of the tailings, water, and binder; conditions on the site above and below ground; chemicals used in flotation and thickening; and required properties such as flowability and compressive strength gain at certain time intervals, a tailor-made formula was designed for the backfill mix.

Introducing a backfill admixture enhanced the rheological properties of the cemented paste, driving further dewatering of the backfill mix design and increasing solids content from 77% up to 79%. Since the UCS significantly improved it was possible to consider a cement reduction from the originally designed 4.5% to 3.5% (Table 1), and even in some cases down to 3%.

Evaluating results, it was concluded that the changes have delivered significant savings in cement consumption a and decrease in operational costs, which was a primary goal of the project study. Calculating the parameters and costs related to the backfill operation, there was an increase in solids of 2% and a reduction of the binder from 4.5% to 3.5% equated to a 20.2% reduction in the binder used, a water reduction of 8.7% and an increase of 3.67% in the tailings that could be used underground (Figure 1).

As shown in Figure 2, a significant change in consistency can be observed between the sample without an admixture and the sample with one. This change in consistency allows an increase in the solids content and a decrease in the proportion of cement, whilst maintaining the same or better flow and the same or better UCS. Note that the cost savings calculated here do not include savings in surface operations, such as a smaller footprint for the tailings on the surface; reduced water consumption and processing; fewer delays due to plant blockages; and reduced maintenance costs.

This practical example shows how collaboration within different departments of a mine, combined with a holistic approach and a good understanding of the process parameters and how they interact leads to the optimisation of several aspects. Using chemical additives in various stages of dewatering and backfilling has been shown to significantly improve the cost structure of the mine. This approach can also improve the reputation of a mining company, demonstrating a responsible approach to conserving water and managing tailings to mitigate potential risks.

Working with its mining partners, Master Builders Solutions can contribute its own multidisciplinary team that includes mining experts, materials scientists, and specialist chemists. By working together, there is an opportunity to see problems from different perspectives, question the way things are done, and make changes for the better by delivering more sustainable solutions.

Conclusion

When embarking on a project such as this one, it is important to set well-defined targets that relate to the whole mining cycle, rather than to just one of its constituent parts. To get the best results it is important to consider the full picture, from material properties to conditions on site, to the equipment used and the process itself. GMR