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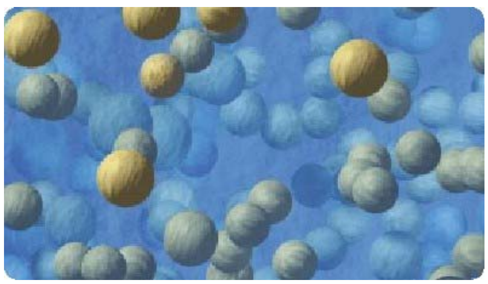
What's in your water?

Author: Andrew Okely

Water management is clearly one of the critical issues facing the mining industry. In recent years, much effort has been invested in both the research of water recovery technology and its implementation. There are two main reasons for maximizing the recovery of plant water, preservation of a limited resource and protection of the broader environment from contaminants in the plant water.



With such a focus on reusing water, it is important to consider what chemicals and ions are in the water and how they may impact on project performance. Three potential situations are examined in this article:

• Recycling valuable reagents

• Recovering valuable components

• Recycling harmful chemicals

Recycling valuable reagents

Project economics dictate that we operate our mineral processing plants with a slight excess of reagents. The incremental cost of the next unit of reagent is generally outweighed by the incremental benefit of the next unit of recovery. This being the case, we find excess reagents reporting to the tailings stream. Reagents, such as cyanide in a gold leach circuit, or collector from a flotation plant, are typical examples. These reagents represent a sunk cost to the operation, thus any recovery and subsequent use of them will provide greater economic efficiency.

Taking the example of a tailings thickener in a gold leach circuit, we find that the greater the water recovery in the CIL tails thickener, the lower the overall consumption of cyanide. This generates two financial benefits in some cases, the obvious saving in cyanide consumption, coupled with a reduction in cyanide destruction costs. Residual cyanide in the tailings stream must be chemically destroyed by either natural UV and time in a tailings pond or by reaction in a cyanide destruction circuit. In either case, management and processing costs are incurred.

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An example of where recovery of cyanide has been effectively achieved was reported by Pajingo Gold mine in Queensland. In this case, the application of a paste thickener on the tailing stream resulted in an 18% reduction in cyanide consumption.

Recovering valuable components

Improving the recovery of plant water from tailings at the Pajingo Mine also demonstrated an example of increasing the overall recovery of the valuable component. In this case the Pajingo tailings contained gold complexed with cyanide which was lost in the liquid phase of the tailing stream.

Outokumpu's paste thickener at Pajingo

By increasing the thickener underflow density a proportion of this gold was recovered. Pajingo reported an increase in overall gold recovery as a result of optimising water recovery.

Other operators that have the potential to see increased recovery of the valuable component by increasing the density of tailings streams include copper and nickel leach circuits.

Recycling harmful chemicals

Unfortunately as with most metallurgical processes, there are situations where increasing the volume of water recycled from tails may have detrimental effects on the plant performance. In these cases sending all the process water to tailings would be ideal but generally the necessary fresh water to do this is not available.

An example of this problem can be seen in some base metal flotation plants. Many base metal operations have metal cations in the process water, generally introduced during the grinding process. These cations can change the electrochemical potential of the slurry, making flotation less effective. Conditioning steps are then needed to modify the electrochemical potential with either reagents and/or aeration. Clearly this results in additional processing cost. The problem of detrimental cations is exacerbated when those ions are being recycled in the recovered tailings water.

Conclusion

Maximising the recovery of process water is virtually a pre-requisite in today's Australian operations. In some situations, this will provide opportunities to improve the economics of the operation and in others, can create significant metallurgical challenges. The key to maximizing the opportunity or minimizing the processing difficulties is understanding what chemicals and ions are in the water.

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Planning for mill installations

Author: Peter Nilsson

Outokumpu Technology's SAG mill at Sally Malay

Photo reproduced with kind permission of Hugh Brown

The milling/grinding area is traditionally known as "the heart of the plant". So, when it comes to preparing the installation of a plant's "heart", a great deal of planning is required. The following article outlines some commonsense steps and pointers which are crucial to this planning process.

Step 1 - Preparing the method statement

All safety aspects, especially how to handle the large components, must be the primary consideration when planning any large mill installation. If you can look through a particular installation job with all its peculiarities and challenges (be it a shell- or trunnion-mounted bearing mill, or a mill on riding rings mounted on the shell) and can clearly envisage how you are going to site rig all the components, you are in effect, mentally forming your method statement which you will have to produce to the engineer at some stage. This, in turn, helps with organising the special equipment you need to take when building the various possible configurations of custom built grinding mills.

Step 2 – Preparing the schedule

Once you have written down your method statement, preparation of the activity schedule is the next task. It is advisable to separate all the different tasks into groups. One method would be to group tasks according to how the various sections of the mill itself are assembled. Once you have an overview of issues like timeline, resources, personnel and tools, you are better prepared to ensure full efficiency with the workforce during the installation. Another benefit of a well-prepared activity schedule is that it then doubles as a progress report of the job itself during the actual installation.

Step 3 - Selecting the right crew

In today's marketplace where there are such acute shortages in qualified technical staff, ensuring you have the right crew for the job has never been more difficult. The tradespeople you select must have heavy fitting experience and be trained in use of all the different technical equipment aspects of the jobs tasks. For example, both the use of laser alignment for the drive train and also ultrasonic bolt micrometers for measuring the elongation of critical fasteners are mandatory standards today. The people you select for the handling and rigging must have heavy lifting experience and preferably have worked in a similar industry for at least some 10 years. 100 tonne section lifts are becoming commonplace these days as processing plants become larger, so there are pitfalls awaiting the inexperienced - graphically documented on some websites.

Purpose built certified lugs on mill shell

Special installation stool, bolted to bottom of mill shell. This helps set the height of the mill shell barrel centre line, holding it stable before the other half is fitted.

Step 4 – Selecting the right tools

Selecting the right tools sounds easy enough – but this can be a minefield to the inexperienced! The list can be mind-boggling – an experienced provider's 'toolkit' can cost $300-400,000. Items in a tool container could include temporary power generator, specially designed lifting equipment, computerised laser alignment equipment, a hydraulic torque multiplier for the large critical fasteners and temporary oil lube systems for floating the mill during construction as the main operational equipment is usually still being installed and without mains power.

The correct clamping force on structural mill bolts is vital as these bolts are designed to last the lifetime of a mill, so choosing the right tool is crucial. An ultrasonic bolt micrometer, for example, measures the elongation of a bolt much more accurately than the 'old ' (and, unfortunately, still used) method of just measuring the torque.

Apart from ensuring a supplier has an adequate toolkit, there are other tooling issues to also consider. All rigging equipment and specially designed attachments, for example, must be certified for use and the certification must be up-to-date. Items such as slings must be checked and registered before sending to the project.

Step 5 Planning your delivery timeline

In order for the installation to flow smoothly, component delivery to site must be such that it arrives to compliment the progress of the installation. This avoids congestions and double handling. The weights and size of components means crane reach and practicable working space adjacent to the mill installation are usually at a premium.

Some pointers to consider

Depending on a project's location - be it the tropics or a dusty desert environment - a lot of large tarpaulins are needed to protect the machined items from rust corrosion or contamination while the machine is being erected. Some large mills take up to 12 – 14 weeks to build and rust/dust prevention is an ongoing task that has to be monitored through the whole erection of the mill.

During the main mechanical erection it is good practicable sense to involve the operational and maintenance staff as much as you possibly can. Usually the various components are already exposed, thus enabling 'hands on' visual explanations. This is important not only for smooth day-to-day operation but also when it comes to choosing long term critical maintenance spares other than commissioning and first 12 month run spares. Site operators and maintenance crews will feel more comfortable with the machine if they are involved from the beginning of the mill erection. It is human nature for people to look after a machine better if the correct operational aspects are understood.

Installation of scrubbers at Ravensthorpe

Commissioning is very important for compiling all electrical settings and actual starting reference trend data for monitored components, including the mechanicals. The mill charge is normally increased gradually to full load over some days. The drive train sometimes has to be reset to suit the hot alignment and dynamic conditions experienced by the mill as load is gradually increased. Site mill staff should keep handy and retain copies of all the final full load starting data settings for reference against what were new as built data readings.

“House keeping” on mills is also very important and cannot be overlooked. This is especially the case for those who operate in a wet area and, in the case of SAG mills, usually a messy area. It’s a well-known milling fact that when house keeping has been well maintained, there are far less instrument and mechanical problems. Care, however, should be taken when hosing down around any bearings. Operators should be made aware of what can and cannot be hosed down.

Conclusion

There are so many hundreds of different things to look out for when planning and building large heavy machinery. These can range from the day scabbling of latent concrete float starts, through to final paint and punch lists, that this is just a ‘taster’ of the issues to consider. The best advice, when it comes to planning the erection of a large mill, is to *get advice* from an experienced professional who can either assist in the project planning or manage the mill erection completely – either on a stage-by-stage basis, or from start to finish. After all, a plant’s “heart” is key to optimum performance in a plant. And if poor planning and/or lack of experience in certain issues results in poor performance, time wasting or, worse still, regular breakdowns, this is something which is not only easily avoided but also makes very sound economic sense.

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Is the last drop worth it?

Author: Ian Arbuthnot

Considerable progress has been made in the last 15-20 years in developing thickeners capable of producing higher density underflows. This follows the increasing demand from the minerals industry for higher densities, which is driven by the economics of tailings disposal and some process issues.

In particular, high density tailings allow more economic disposal methods (e.g. CTD, “dry stacking”), while at the same time recovering more water and hence reducing water make-up costs; whole tailings can be used where appropriate for mine backfill – which can both reduce underground mining costs and in some cases extend mine life; and in some processing applications, operating costs and/or capital equipment costs can be reduced.

Some definitions

In order to progress any discussion in this area, it is necessary to be reasonably clear on the definitions to be used. To distinguish between “high density slurry” and “paste”, a yield stress (YS) transition of 200± 25Pa has been proposed (Ref. Jewell, R.J., Fourie, A.B. and Lord, E.R. “*Paste and Thickened Tailings – A Guide*” ACG (2002)). Above this transition is paste, and below this is “low”, “medium” and “high density” slurry. A high density slurry would be non-segregating and would still flow down a slope, and would have a YS up to about 200Pa; a paste would exceed this YS value, would generally require positive displacement (PD) pumping, and would not release a significant amount of surface water once deposited. Care still needs to be taken in using these definitions, since the YS of a thickened slurry or paste is affected by its shear history – this is discussed further below.

A “slump test” (and hence the term “slump”) is used in some situations to describe the behaviour of a high YS slurry. This is a simple standardised test which measures the degree to which a material slumps when placed on a flat surface, and is inversely related to the YS of the material.

Further background reading material on these concepts can be found in the excellent publication “*Paste and Thickened Tailings – A Guide*”, referred above. A second edition of this guide has just been printed.

Applications

The main minerals processing applications where higher density thickener underflows have been used are, briefly:

1. **Tailings disposal** - For above-ground surface storage rather than the conventional tailings dam, a High Density non-segregating slurry is required; likewise for the “Down-Valley” style of disposal, in which the tailings material must flow, but should exhibit a planar slope in its beaching characteristics.

2. **Mine backfill**: - Whole (coarse and fines) or part tailings (coarse only) are used – very specific flow and strength requirements must be met by the material used. Where the whole tailings stream is used, it is generally necessary to achieve paste consistency. This has usually been done by filtration and repulping – but the new generation of paste thickeners offers an alternative here.

3. **Autoclave feed**: For autoclave leaching circuits, such as laterite nickel applications, the feed material is typically very fine and as such difficult to thicken to high density. However, the autoclave is generally an expensive item and reducing the feed volume by increasing the density is usually economically attractive. Production of paste for this application may show clear benefits.

4. CCD applications: The washing efficiency of a CCD circuit is strongly dependent on the underflow density from each thickener stage. For a selected washing efficiency, it is a matter of direct economic analysis to determine whether to opt for higher density thickening in order to reduce the number of CCD stages, i.e. whether the reduced number of thickener units offsets the increased cost of producing the required higher underflow density.

Tailings Thickeners

Of the applications described above, tailings disposal is common to most mineral treatment operations, and hence a lot of effort has been expended by the major thickener manufacturers in developing thickener technology to suit the changing needs of tailings disposal systems. For either CTD (Central Thickened Discharge) or down-valley discharge, the need is for a high density slurry. Typically, the YS at the discharge point would be in the range 10-30Pa. For “dry-stacking” of tailings, usually involving the separation of coarse and fine tailings and utilization of the coarse fractions for layering and embankment construction, the thickened fines fraction is typically thickened to a somewhat higher consistency than CTD, i.e. a YS of 30-100 Pa

Although the above YS ranges do not appear to be in or close to the paste regime, the shear history of the discharged material needs to be considered. If a tailings stream has to be discharged at the end of a pipeline at a YS value of 100Pa, it is quite likely that the YS in the thickener would have to exceed 200Pa, since the shearing that occurs within the pumps and tailings pipeline causes significant structural breakdown of the thickened slurry matrix, and hence reduction in YS. This is a function of the pump type (centrifugal or PD) and flow regime within the tailings line. Hence the thickener requirement may be to produce paste (as defined above), whereas at the disposal point the material no longer has paste consistency. However, if the required YS is say 30Pa at discharge, then a high density slurry underflow of YS ≤ 150Pa would probably suffice.

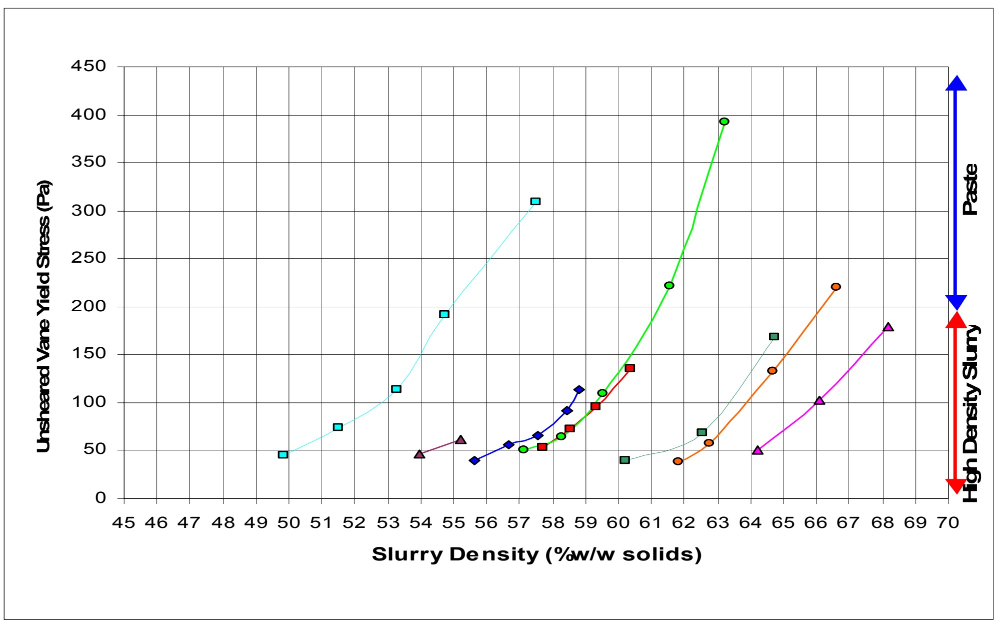

Figure 1 - Yield Stress vs Slurry Density for various copper ore blends within a single mining zone, ranging from pure oxide on the left, through various blends to primary sulphide on the right. Note that whereas the actual YS values are quite different for the differing ore blends, the "exponential" shape of the curve is common.

Because of the significant increase in capital and operating cost in using PD pumps, process designers usually favour installing centrifugal pumps even for quite high YS slurries. A common technique used to present a lower YS slurry to the tailings pumps is to install an underflow recirculation circuit incorporating a large centrifugal pump. This reduces the YS of the thickened material in the underflow cone of the thickener, making it more fluid and easier to pump long distances to the tailings discharge point.

Clearly, the thickener designer can be faced with a number of differing scenarios for tailings thickening. Referring to the exponential YS–slurry density curve (Figure 1), it is a matter of considerable interest to the designer whether the thickener is to operate in the medium density, high density, or paste regime.

To meet this challenge, Outokumpu Technology has developed three generic thickener models, namely: High rate – bed depth to 2.0m: High compression – bed depth 2.0-4.0m and Paste – bed depth 4.0-8.0m.

The illustrations below show the difference in tank configuration of these three models – it should be understood that there are also differences in the rake mechanism and drive train design, notably in the torque capability of each type.

High rate thickener – low sidewall depth

High compression thickener – increased sidewall depth

Paste thickener – very deep sidewall, increased floor cone angle

These thickener models are distinguished by the compression zone or bed depth rather than the consistency of the underflow. The underflow consistency is a product of both the thickener configuration and the material characteristics. Hence, for example, some tailings materials may be thickened to YS values of +200Pa in a high rate or high compression thickener, whereas others may need a very deep paste thickener to achieve the 200Pa level

Testwork

For a given mine site, it is quite common for mineral processors to take the view that the “highest possible” tailings consistency is required. This may lead to a quite arbitrary tailings density being specified (e.g., “70% w/w”), and the thickener manufacturer is then asked to demonstrate that he can achieve it. As ore characteristics can vary within a mining zone, the thickener manufacturer would need to be provided with an appropriate range of tailings samples and the required underflow density for each.

An alternative approach would be to firstly determine what tailings disposal methods are feasible, which will set the required “slump” or YS at the discharge point. The benefits of such an approach include avoidance of unnecessary equipment to cope with the arbitrary 70% w/w specification and an optimised thickener design which can far more accurately manage the varying ore characteristics throughout the life of the mine. Outokumpu Technology’s test laboratory in Perth has the capability of relating this requirement to the targeted thickener underflow by carrying out the appropriate shear/YS measurements on the underflow sample.

In the picture to the left, for example, the vane rheometer at Outokumpu Technology's Perth Laboratory is used for YS determination on thickener test unit underflow samples.

This approach of carrying out a full dynamic test on each sample, and measuring both unsheared and sheared YS on the underflow (as with the vane rig across), provides a high degree of confidence in the thickener configuration selected and the predicted performance.

Conclusion

Whether to thicken mineral plant tailings to the ultimate achievable density is a question that needs to be assessed carefully. Often, thickening to the absolute 'last drop' is an unnecessary exercise as determining a slurry's rheological properties is the more efficient and reliable means of delivering the required thickening result.

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