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Outotec
More out of ore

Sustainability – through modernisation and optimisation

Author: Richard Jenner

Every mining operation has budgets, production targets, business goals and a sustainability plan. Each of these operations aims to minimise capex, reduce opex and downtime, and increase profit and productivity. On top of this, there is growing pressure to be better corporate citizens, reduce our carbon footprint, and improve water management. Challenges we cannot control add further to the mix, such as metal prices and global economic performance. Achieving budgets and business goals requires the efficient use of all internal resources, such as; people, plant, raw materials, maintenance, reagents, and procedures.



How do you achieve these goals with current resources?

Globally, mining operations are faced with the same general challenges. Ask any plant manager if they are operating efficiently, and within original design specifications, and the response will resoundingly be “no”. This is due to many reasons - capital constraints, increased throughput, ore composition changes, aging plant - these are just some of the challenging variables.

Other factors could include manually operated equipment, high staff turnover, resulting in loss of local knowledge, limited personnel numbers who are focused on operation with no time for projects.

Without responding to these factors, the sustainability of an operation is threatened, and the consequences are obvious; plants run at low efficiency, with high operating costs, lower than desired grade and recovery, high maintenance costs, and so on. To achieve sustainability, plants must optimise and modernise.

Most sites have a good idea where their operational bottlenecks are, or which part of the plant is causing the most problems, but where should you start?

Process audits are an excellent way to benchmark current performance, review current operating and production targets. They are also extremely useful in identifying projects to meet or exceed budget targets and business goals. A process audit will answer the tough questions that threaten your sustainability.

- How do I get that extra 3% yield?
- How can I reduce water consumption?
- How can I reduce my power usage without reducing productivity?
- What gains can be achieved without capex?
- Where can I spend my limited capex for maximum returns?

The scope of a process audit will depend on your needs, and can range from basic to detailed, with either a narrow single process stage focus or broader site wide perspective. Depending entirely on the scope, a process audit may include:

- Site-wide mass, energy and water balance
- Overall and unit efficiency of existing plant (grinding, thickeners and flotation)
- Mechanical condition of existing plant (grinding, thickeners and flotation)
- Identification of bottlenecks and root cause analysis of performance issues
- Corrective actions and improvement opportunities identification
- Budgets, scoping, engineering, contracts, implementation, gains!



A skilled process audit team will approach your operation from a number of perspectives to determine your needs, including: metallurgical, process, mechanical, operation, maintenance, and personnel training. Looking at a minerals processing plant, the following are just some of the potential benefits from a process audit:

Grinding

Particle size distribution and electricity consumption are the two main concerns for any grinding circuit. A process audit in the grinding circuit will:

- Determine optimum particle size distribution for maximum recovery
- Outline a process for efficient mill control
- Determine any potential for reduced power consumption

Flotation

Flotation has come a long way since its inception over 100 years ago. The rate of technology development continues to increase rapidly. As a result of this, most new technology is designed to be retrofitted to existing flotation machines. The flotation circuit is where the quality and quantity of your final product is determined. Minor changes in the operation or design of the float circuit can have an impact on your bottom line worth \$millions. A process audit can result in benefits such as:

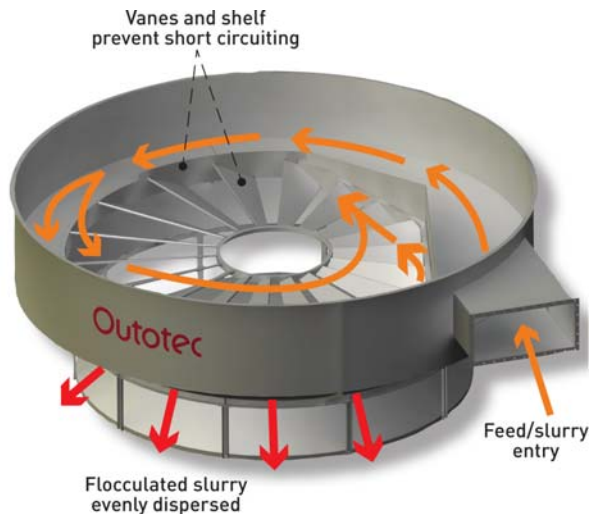
- Increased throughput of existing circuit
- Metallurgical performance improvements
- Step change power draw reduction
- Safer, quicker maintenance turnaround
- Reduced wear of consumable spares

For example, following a collaborative process audit at a gold mine in New Zealand between the site's metallurgical team and Outotec, it was determined the flotation circuit had inadequate flotation capacity, sub optimal recoveries, with high operation and maintenance costs. Following Outotec's installation of three TankCell® - 300s and automation technology, gold recovery increased by 3%, and the circuit was easier to maintain and operate.

Thickening

Only minor deficiencies in thickener control can have a significant impact on downstream processes – dirty process water, high moisture filter plant feed, poor water recovery, high flocculant usage, and so on. The fact is, achieving effective thickener control is simple and economical.

- Am I achieving optimal underflow density?
- What benefits would I get from improved thickener control?
- Is my feedwell suitable for the current duty?
- Can I fix the froth problem?



Outotec's new Vane Feedwell, a significant performance enhancer in the industry.

Potential audit benefits:

- Increased throughput of existing thickener
- Reduced flocculant usage
- Optimised underflow density control and moisture reduction
- Steady, reliable thickener control
- Improved water recovery and clarity
- Elimination of menacing froth problems
- Simple, cost-effective thickener retrofit, thereby minimising capex

For example, a process audit was performed on a mineral sands thickener. Following the audit, a new feedwell design was installed. This resulted in flocculant reduction of 10-20%, throughput increased by 10%, with less variability in underflow density.

Automation

This is another area which can quickly yield results if the correct process and technology are in place. Typical questions to ask before determining the need for a process audit are:

- What does better level control mean for my circuit?
- What is the best way to automate my reagents?
- Am I getting the most out of my on stream analyser?

Spares, service, maintenance and training.....

- Am I carrying enough critical spares to stay online?
- Do I know the lead times for critical spares that I don't carry?
- Is my preventative maintenance program suitable?
- Do my operators have the skills to run my plant optimally?
- Do we know how to effectively troubleshoot process upsets?

Answering no to any of these questions represents a risk to the sustainability of your operation. Not only will a process audit answer these questions, but will outline the corrective actions necessary to achieve sustainability. So it pays to ensure you are talking to the right people. Whether it is auditing your on-site technology such as the grinding or flotation circuit, making sure your operational staff are operating at absolute maximum efficiency through customised training packages or ensuring you have competent spare parts and maintenance programmes, the right people can make all the difference. And in today's market, with all the challenges facing mining operations, staying ahead is particularly critical.

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Maintenance and safety improvements in flotation cell design

Author: Jason Amaranti

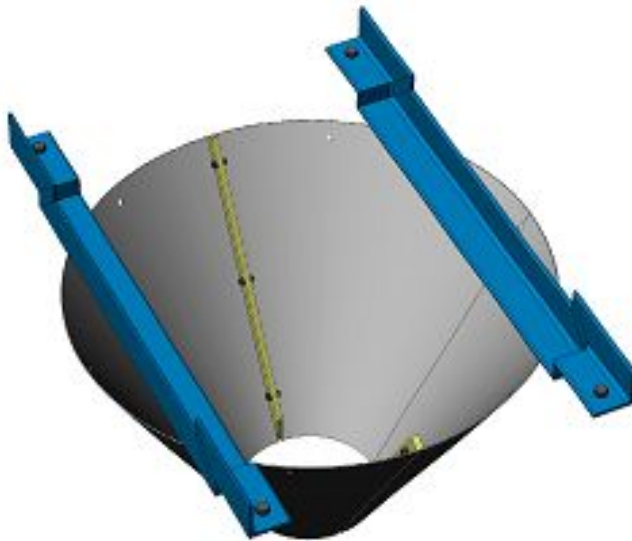
Maintenance shutdowns are critical in ensuring a mining plant operates at full capacity. With a specific block of time allocated to complete a schedule of tasks, it is imperative these tasks are completed in a safe and timely manner. Although it now seems like decades ago, the mining industry's unprecedented growth spurt up to 2007 resulted in high staff turnover. Consequentially, this rotation of staff has resulted in longer times to complete maintenance tasks. Improvements in maintenance tools and procedures can not only make life easier for maintenance and operation staff, but can also improve a site's bottom line.

This article will look at three main areas in flotation maintenance - these being design, procedures and tools.

Design

There are many small design features in a modern flotation cell which can improve maintenance, whilst still keeping it safe and effective.

The flotation mechanism is the heart of a flotation cell and combines a rotating part (rotor) and a static part (stator). Most rotors and stators nowadays are engineered for easy replacement with common flange mounting details. Stators can also come in sections to allow safer and easier handling.



FrothBooster cone, with maintenance beams

FrothBooster cones, for example, are fitted in Outotec flotation TankCells® to reduce the open surface area in the flotation cell and optimise froth handling. Booster cones decrease the distance the froth has to travel to reach the launders. Process conditions will decide the diameter of the booster cone. To ensure maintenance of these booster cones, they have been designed to split into two parts and the bolts are then sikaflexed to protect them.

Another simple innovation is the introduction of sample hatches into a float cell design. Sampling of flotation cells is critical in monitoring performance. On some sites the removal of grating on top of a flotation cell requires hard barricading and permits and this can really hamper the operators' efforts. Outotec's sample hatches allow froth lip samples to be taken, depth samples from within the cell and access for a bubble viewer to monitor bubble size and superficial gas velocity.

Rectangular froth discharge outlets have been another important development, allowing the froth to flow freely from the flotation cell. There have been examples in the past where a round outlet has restricted flow and this has affected flotation cell performance. It is also recommended that the transition piece between the outlet and the launder has a slope, thereby ensuring the froth is cleanly taken away from the flotation cell.



Rectangular froth discharge

Although a pretty obvious solution, the addition of access doors provides a safe method for entering and inspecting flotation cells on a maintenance shutdown. The access doors on Outotec's TankCell and SkimAir units have been designed so that the only tool required is a suitable hammer to release the locking plates. The design is simple, yet effective.



Access doors

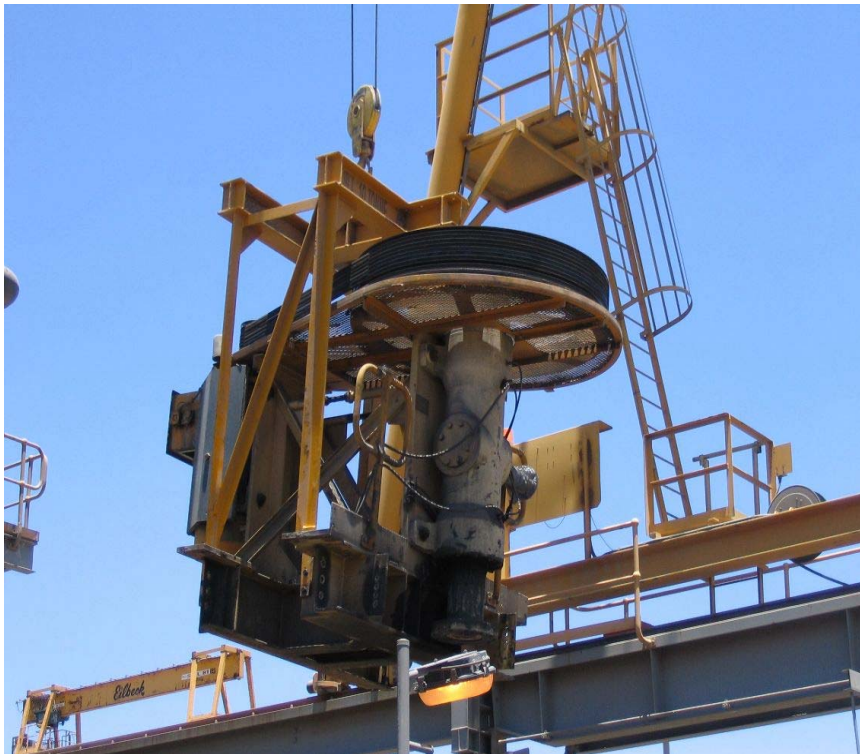
Another design area to review is valves. When pinch valves are sized, for example, it is normal to design to the maximum flow. On some applications, the diameter of the discharge flange is increased to the next size, with a reduced bore sleeve for the pinch valve. This enables the site to increase the sleeve size and, therefore, throughput when required. It allows greater flexibility in design and does not require any modification of the flotation cells.

Procedures

Simplifying procedures and using adequate tools can optimise time and safety in flotation cell maintenance. A regular review of procedures can help simplify the number of steps required, whilst making safety a priority. The procedures for a motor change-out, for example, could be illustrated in the simple process below:

Rotor change-out

- Drain flotation cell and flush with water
- Isolate drive motor and disconnect wiring
- Remove pulley cover
- Remove all rack bolts
- Attach lifting frame to drive rack
- Position maintenance beam
- Attach lower shaft and booster cone
- Unbolt upper shaft and lower shaft flange
- Lift out main drive rack



Lifting frames for flotation mechanisms

Tools

The final piece of the puzzle relates to tools which help ensure that flotation cell maintenance become as effortless as possible. Outotec, for example, currently supply a lifting frame and maintenance beam that provides a safe alternative for completing maintenance of flotation mechanisms. Cradles have also been designed to support Outotec flotation mechanisms, creating a safer working environment. These cradles can be designed to carry a range of different sized mechanisms.

Conclusion

The completion of flotation cell maintenance in a safe and timely manner is not something to be overlooked. In fact, with the correct design, procedures and tools in place, significant manhours can be saved, whilst still ensuring safety is a high priority.

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Thickener sizing and the importance of testwork

Author: Andrew McIntosh



1m pilot test rig

In this current climate, with scrutinising eyes fixed firmly on the bottom line, cutting corners on the costs and effort associated with testwork at the early stages of a project may appear attractive. After all, surely relevant experience combined with some calculated guesswork, can't go too far wrong? However, the sizing of equipment which achieves design requirements and is not conservatively oversized can influence both the financing of a project as well as its long term operational success. The following article goes back to basics, outlining the different options available in thickener sizing, from rudimentary through to highly comprehensive, and explains where each method is appropriate.

Factors affecting thickener sizing and performance

When planning a project that includes thickening technology, a key element in the process is determining the sizing and expected performance for the thickener(s). This information will facilitate project layout and design, as well as define capital expenditure and operational cost estimates.

As thickener performance will have a direct effect on overall plant operation, Process Performance Guarantees from suppliers are generally expected. In certain cases these guarantees are a pre-requisite for the project meeting financing approval, so can be a critical element at early stages.

Thickener performance parameters, such as underflow densities and overflow clarities, and the effect of feed variables such as rise rate and solids loading rate, can vary greatly for different thickener feeds. Even for the same types of application, thickener performance will vary at different sites due to factors such as particle size, the presence of clays and organic materials, water chemistry, and the effects of upstream processes such as grind size and the use of reagents.

Other parameters, such as the optimal feedwell slurry density for efficient flocculation, and the type and dosage of flocculant will also vary from application to application. These parameters will have an effect on the project's capital and operational costs. For example, a particular application may require additional dilution of the incoming feed stream via the use of self-diluting systems (such as Autodil or Turbodil) to add supernatant liquor from the thickener surface into the feed stream, while another application may require underflow re-circulation to seed the flocculation process due to a highly dilute thickener feed.

Thickener sizing methods

Depending on the stage of the project, and whether or not samples of indicative feed material are available, a number of different methods can be used to determine thickener sizing. In general, these can be classified as: rule of thumb sizing, cylinder settling tests, and, lastly, dynamic thickener testwork. These methods differ in levels of complexity and outlay (in terms of time and effort as well as cost) and correspondingly vary in their level of accuracy:

1. 'Rule of thumb'

Sizing is based upon experience with the particular thickening application, and is used in cases where indicative feed samples are not available, or for preliminary sizing purposes. Performance achieved at adjacent sites with similar feed types can be taken into account, if this data is available.

Generally 'rule of thumb' sizing is utilised at the early stages of project conceptual studies and for preliminary budget pricing purposes. This method is the least accurate method of the three, as assumptions are made re feed material displaying 'typical' properties for that particular application, and site-specific factors (such as high clay levels) can be overlooked. For this reason, it would be unusual that a definitive supplier's Process Performance Guarantee would be provided based upon rule of thumb sizing.

Often, due to the low level of accuracy associated with this method of sizing, it is necessary to allow for high safety factors on the sizings. This can lead to conservative sizings and therefore larger size thickeners than required, driving up project costs unnecessarily. Conversely, where feed materials display particularly poor settling characteristics, it is possible for the thickener to be undersized, leading to process performance being below specification.

2. Cylinder Settling Tests

These tests and the various mathematical methods developed to interpret their results (such as the Coe & Clevenger, Kynch, and Talmage & Fitch methods) were the traditional method for thickener sizing until the 1990s. These methods are a step up from rule of thumb sizing and provide more accuracy. Cylinder settling tests (or jar tests) can be conducted with a relatively small amount of indicative feed sample, less than that required for dynamic thickening testwork.

From the results of cylinder settling tests, interpolations can be drawn as to the expected underflow density in the full size thickener. Optimal feedwell conditions for flocculation can also be ascertained.

The downside of cylinder settling tests is the lack of accuracy compared to dynamic testwork, since they do not account for the effects present in full-scale thickening, such as the rotating mechanism. To compensate, it is again necessary to allow for additional safety factors.

3. Dynamic thickener testwork

This is the method through which the most accurate thickener sizing and prediction of process performance is achieved.

Most reputable and experienced thickener suppliers have developed a number of dynamic testwork units of various sizes and configurations. These dynamic test rigs are essentially scale versions of commercial thickeners, with feedwells, flocculant addition, underflow pumps, and rotating rake mechanisms to duplicate the full-scale thickening process.



190mm pilot test rig

For example, Outotec carry out most dynamic testwork in a bench-scale 99mm internal diameter test rig. Other tests rigs include a 190mm internal diameter with extended wall height to simulate the additional compression in paste thickeners, and 1m diameter test units of various sidewall depths. The 190mm and larger tests rigs are used for paste thickening applications and other larger scale test campaigns.

Generally, due to the amount of sample required, paste thickening and larger scale testwork campaigns are conducted on-site. This is also the case for bench-scale testwork for feed types expected to age significantly during transport or where the water quality characteristics will affect results of testwork.

Dynamic testwork presents a number of benefits including:

- Ability to accurately ascertain the relationship between feed solids loading rate and underflow density and overflow clarity, and flocculation requirements.
- Any requirements for feed dilution or solids recirculation to achieve optimal conditions for flocculation can be determined.
- The safety factors necessary with less accurate sizing methods are not required. This leads to lower costs in most cases as smaller thickeners can be specified.
- Process guarantees are available on thickeners sized using this method, thus fulfilling any requirement for guaranteed thickener process performance.

Ensuring that the most accurate testwork possible is utilised can mean the difference between achieving your desired thickener performance and 'almost' achieving it. 'Almost' achieving process targets can lead to problems such as: Ability to accurately ascertain the relationship between feed solids loading rate and underflow density and overflow clarity, and flocculation requirements.

- Unnecessarily high operating costs due to non-optimised flocculant consumption.
- Unacceptable thickener overflow clarity, meaning possible inability to recycle plant process water.
- Downstream effects on other equipment in the circuit such as, for example, filter operation.
- Complications with underflow pumping or other intended transportation methods.
- Problems with tailings disposal, such as unstable tailings deposition, tailings disposal volume consumed at a higher rate than envisioned, additional rehabilitation costs.
- Inadequate washing – CCD circuit.

So, in summary, in the early stages of a project, rudimentary rule of thumb sizing can fulfil basic requirements. However, the temptation to scrimp on the costs and effort associated with testwork can have lasting ramifications. Comprehensive dynamic testwork performed on indicative feed samples ensures truly optimised thickener performance, achieving process targets and minimising operational costs. It can also avoid costly conservative oversizing, which can mean the difference between whether your project proceeds or not. As tends to be the case in life, investing a little bit of expense and effort up front can save substantial costs and avoid disappointment further down the track.

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