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How can we capture the knowledge people generate?

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We see it every day and in every part of our lives - the importance of working with good people. Much of what we do to improve the technical performance of our minerals processing plants is driven by highly competent people. People who have the ability to analyse and understand a complex, interdependent system and find ways to make significant improvements.

The problem is, there are not enough of these people to cover all of our operations. How many times do we see plant recoveries improved by 1 or 2% through the efforts of an individual galvanising the team, only to see that successful individual move on to another project and the gains go with them? Improvements are difficult to find, but the true challenge is sustaining them. In the following article I will discuss an example of plant optimisation and then discuss ways to ‘lock in’ these opportunities.

Plant optimisation – an example

I was recently fortunate to attend a presentation which discussed improvements achieved at the BHPBilliton Escondida flotation plant. These significant improvements occurred through a project which applied the latest thinking and investigative tools available in the flotation discipline.

The aim of the project was to optimise the performance at the two copper flotation concentrators at BHPBilliton’s Escondida copper mine in Chile. This project was undertaken by a team from JK Tech, lead by Dan Alexander, and is the subject of an excellent paper presented at the 2006 CMP conference in Ottawa, Ontario, Canada.

A number of differences between the two concentrators at Escondida were identified. The concentrators, called Leguna Seca and Los Colorados, were performing at vastly different rates in terms of throughput and concentrate grade. These variations are summarized in the table on the next page.

Although the float cells at the sites were also from two different flotation technologies, the discrepancy in grade and throughput were so great that it was decided to see if factors other than different suppliers and ore could help account for such a variation.

	Leguna Seca (non OT)	Los Colorados (OT)
Feed rate (TPH)	4970	5483
Feed grade % Cu	1.33	1.02
Rougher concentrate rate (TPH)	619	479
Rougher concentrate grade % Cu	8.9	10.0
Recovery grade % Cu	83.1	85.9
Superficial velocity (cm/s)	1.1	1.0
Air hold-up (%)	14	10
D32 bubble size (mm)	2.2	1.8
Bubble surface area flux (s^{-1})	30	30
Resistance time (min)	42.3	29.7
No. and size of rougher cells	54 x 160m^3	80 x 100m^3

During the investigation, a number of contributing factors for the performance variation at the concentrators were discovered. Some factors - such as feed ore floatability characteristics and froth recovery - were obvious ones. However, the project also identified a number of “people factor” influences - including maintenance and operator training - which could have contributed to the lower metallurgical performance of the Leguna Seca concentrator. Plans were implemented to mechanically overhaul the flotation cells at Leguna Seca and additional operator training was provided. This resulted in a significant improvement to the circuit performance. It is clear that the high calibre of people on the project and their years of specialized training helped them identify the opportunities.

How can we capture the knowledge people generate?

Following on from this example at Escondida, I would like to outline three simple, yet key, ways to “lock in” plant improvements and capture them in an on-going basis. After all, the true challenge at sites is always to maintain improved levels when the experts are gone..

1. Maintenance

Benefits derived from improved maintenance procedures should be relatively easy to capture if carefully documented. The risk here is that a change in maintenance staff could negatively impact in the future if procedures, documentation and training are not of a high standard. So ensuring a plant’s maintenance procedures are comprehensively documented and easily accessible by operators is an obvious, yet key, step.

2. Cell Operations

Without doubt, many benefits can be found through better training of flotation cell operators. The challenge in capturing these benefits is the need to provide not only robust initial but also on-going training. Operators rapidly develop their own approach to a given plant which is a combination of factors such as their past experience, the methods used by existing operators and the physical limits of the equipment. A new, influential operator can soon change the practices of a whole crew so training must not only be part of the induction process but provided on an ongoing refresher basis. On-going training also ensures that shortcuts or bad habits which have slowly crept into a plant's operations are eradicated. Any operator training should include topics such as the operating strategy, the reasons that strategy is employed and also more 'hands on', practical areas such as troubleshooting, process optimisation, calibration, maintenance routines and critical spare parts.

3. Technology Capability

This is one area where sustainable gains can be also locked in. Upgrading control hardware and software to automate a new operating strategy is crucial to combating the deterioration in the initial gains, which occur over time. Other aspects to consider are support hardware such as pumps. A change in operating strategy may improve the metallurgy but if there are shortcomings in the materials handling system, operators will soon revert to the old practices.

Conclusion

The Escondida example highlights our ability to identify substantial gains in our process plants. It also illustrates the importance of having a strategy for capturing those gains that relies more upon management systems and technology than it does on individual people.

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Be wise and optimise

Author: Mike Cook

Nowadays, with the commodities boom still hurtling along at breakneck speed, knowing your minerals processing plant is operating at its fullest potential is not just a “nice to have” option, it is a business necessity. Some plants could be losing potentially hundreds of thousands of dollars a day simply by failing to ensure their people, processes and equipment are performing at optimum level. Achieving a high throughput and maximising recoveries is a continuous challenge for all operators, production and metallurgical supervisors and it has been well documented that some site technologies and equipment are often pushed well past their original design capabilities.

From a minerals processing point of view, there are many technologies that could benefit from auditing and/or optimisation. A properly audited site can ensure its operators are adequately trained and any potential safety hazards eliminated. Payback time for such a site can be a matter of weeks or even days.

So, taking a thickener as an example, its inefficient operation can lead to excessive flocculant and reagent consumption, increased solids carry over in the overflow system, reduced underflow densities, increased maintenance routines and inefficient pumping. All of these have a considerable impact on recoveries, environment and maintenance - each of which affect the bottom line.

So, with such compelling arguments, the marketplace has obviously recognised this need and as a result, we increasingly see technology providers, engineering companies and consultants offering “plant audits and optimisation”. So, what type of site could benefit from a “health check-up”?

- Plants which have experienced changes to the original design – either in ore type, throughput or even duty
- Operations which have no formal or systematic optimisation programme
- Plants which are running antiquated equipment
- Plants whose operators have changed. Change of personnel can have a surprising impact on how some equipment is run.

This article will, firstly, look at key elements essential to optimal thickener performance and, secondly, outline the potential steps in a thickener audit/optimisation programme.

Feedwell and feedpipe

Some key thickener elements

1. Feedwell - the feedwell is the heart of any thickener operation. Mixing, deaeration and flocculation are all performed and controlled within the feedwell structure. So, ensuring optimal design can result in efficient flocculation, reduced reagent costs, maximum underflow densities and improved overflow clarity. The following feedwell areas merit “check-ups” - baffle quantity, size and profile; incoming and outgoing feed velocities; feed projection angles; throat dimensions, pitch and depth; dilution quantity and design; and, lastly, flocculant addition methods.

Thickener prior to commissioning

Optimised overflow

2. Throughput and duty - if there is an increase in the thickener throughput which is in the uppermost levels of the original design scope, upsizing the feedwell and feedpipe, modifying overflow boxes, increasing underflow nozzle sizes and providing additional dilution are means of improving performance. If, however, the volumetric feed rate continuously exceeds the original thickener design to a level where the increase in rise rate will compromise the thickener performance, then a larger thickener may be required.

Changes in duty, including rates and feed composition, can adversely affect the drive mechanism. If not controlled or monitored correctly, these can impact on torque loads and the controls. It is important to manage a thickener's inventory whilst maintaining an adequate safety margin for recovery in a high torque scenario. Operating continuously with high torque loads or high torque spikes can result in lengthy downtimes due to "bogging" or even maintenance shutdowns as a result of the increased wear rates.

3. Feed mixing – it is critical that the feed becomes homogenous once it enters the feedwell's mixing zone. A nominated retention time should also be maintained to allow for deaeration and efficient flocculation. The feed must enter the feedwell at a given rate and gently rotate with a controlled agitation that enhances the mixing and flocculant contact process. Excessive agitation can cause the flocculant to shear, leading to high flocc consumption and a high yield stress with minimal density gain. Not enough agitation can cause material segregation, poor flocculation, short-circuiting, beaching, torque spikes and a general reduction in performance.

Excessive flocculant consumption can increase the underflow viscosity, placing additional load on the underflow management system. This may appear to improve overflow clarity yet has no real gain in actual production as it may not increase the underflow density. Optimised flocculant consumption can, however, result in the obvious financial gain, improve pumping capabilities, assist with underflow densities and reduce the environmental impact.

4. Thickener rake - over time, a thickener's electronics can drift and decalibrate from simple general wear and tear. So whether a thickener is performing a revised duty or needs fine tuning due to excessive wear, torque loads and drive mechanisms should be audited to determine if the current mechanism configuration and design are adequate. Re-calibration of hydraulic pressures, resetting of reliefs and limits and a full review of the automatic torque management system are easily carried out and highly recommended

Monitoring wear and tear can greatly reduce the equipment downtime and enable a site to efficiently plan their maintenance schedules. In some cases, performing predictive maintenance can increase the lifespan of parts and components, replacing them only when necessary - as opposed to simply replacing them on a frequency basis (often done when using account-based maintenance programmes)

What's involved in your typical audit?

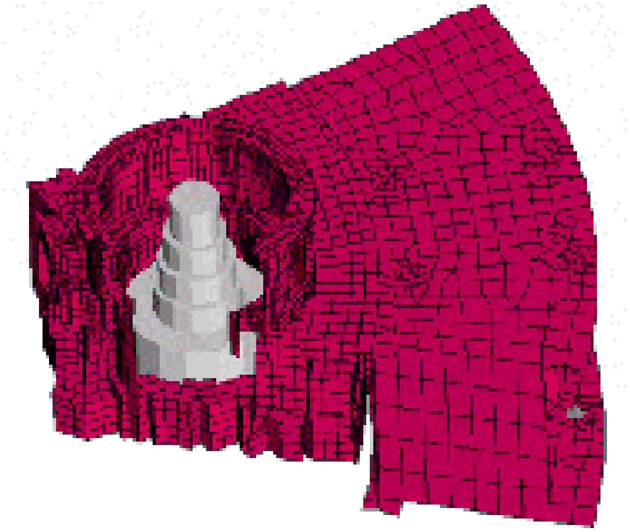
Most credible auditing methods examine mechanical, electrical, instrumentation, equipment configuration and process issues. Following this, potential design inefficiencies, configuration problems and any equipment failures can be determined. If a full mechanical audit is required, then it needs to be performed during shutdown and restarted for the process stage. This type of audit would obviously take longer.

1. The audit - a process and basic mechanical audit commences with ensuring the site's priorities, objectives and plant operation history are clearly understood by all parties. At a minimum, the site's current operating performance and examination of whatever changes, if any, have occurred, are reviewed. Some providers are more interested in selling additional equipment during an audit than actually understanding what the site really needs – so it is important that the audit remains an audit and not a sales pitch.

2. Site visit – during the site visit (typically 1-3 days, depending on quantity of equipment etc) the engineers generally perform the following: observe thickener operation; review trends such as rake torque, bed level and bed mass etc.; record current duty (feeds, particle size, pH, etc); record current performance in underflow density and overflow clarity; monitor mixing in feedwell; and examine flocc formation and consumption.

3. Review process - the information should be collated and reviewed along with current design and equipment configuration using original specifications, original test reports and as-built drawings. If there are any differences between original specification and current duty, a new duty statement would be compiled and used to determine changes for efficient thickener performance.

1m pilot test rig



Simulated torque around column drive, using FEA

4. Testwork – if changes have occurred, testwork is the next logical step to help determine what modifications are required for optimal design. A sample from site is obtained and lab scaled dynamic thickener testwork performed. Any reputable service provider can also carry out FEA and CFD software to design, optimise and individually tailor aspects of equipment. Upon completion of testwork and, where applicable, software modelling, the optimal thickener performance is determined, covering areas such as flocculant consumption, underflow density, overflow clarity and underflow yield stress.

The service provider should supply a comprehensive report that includes all data, testwork and any recommendations or modifications to thickener configuration and ancillary equipment. It should also contain a report on mechanical, electrical and instrumentation condition.

Available options

If there is a need for equipment optimisation or replacement, then a site could obtain indicative capital estimate for the proposed changes. This estimate should include supply, installation and commissioning. Alternatively, a site could request a scoping study that provides a definitive capital estimate for all associated design and construction works.

Conclusion

Plant audits and optimisation programmes are an investment well worth making. Even if a site's duty, orebody or throughput has not changed over the years (highly unlikely) – all equipment, personnel and processes benefit from a "health check". Most reputable service providers will be able to offer a full suite of optimising options after an audit – and not necessarily just recommend buying larger equipment.

Mike Cook is currently Manager - Service Products, for Outokumpu Technology's Australian Service Centre. Mike has highly specialised knowledge in thickening and flotation technologies, amassed during his 16+ years with the company. Previous roles at Outokumpu Technology include 13 years as a Project Manager, followed by the last 3 in the Australian Service Centre, where his process and engineering expertise has been a particular asset. Mike has also played a major role in product and systems development in the Service Centre.

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Dart plug valves – the modern slurry control tool

Author: Peter Bourke

On the surface, it appears not much has changed over the years when it comes to controlling slurry flow in flotation cells. One of the key slurry control elements, the dart plug, has been around for at least the last 60 years. Whilst this basic control remains unchanged, much has changed in terms of the size of these valves, their location within the process, the materials they are made from and the way they are controlled. This article will review the latest technology and see how dart plug valves have evolved from humble beginnings to a modern, highly engineered form for slurry control.

High capacity cells and dart plugs today

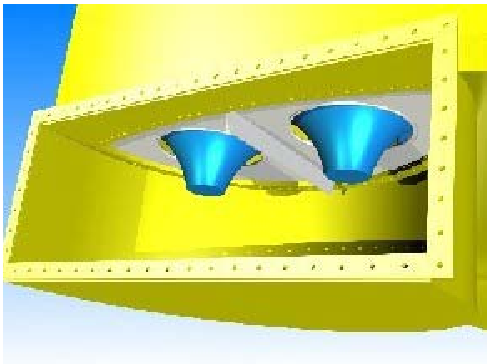
Due to an ever-increasing demand for larger and larger capacity float cells (the largest available model, TankCell® -300, offers an amazing 300m^3 of capacity), the modern dart plug now comes in sizes up to 800mm in diameter. Managing these large slurry flows needs a control mechanism which is up to the task.

The world's largest TankCell® with 300m^3

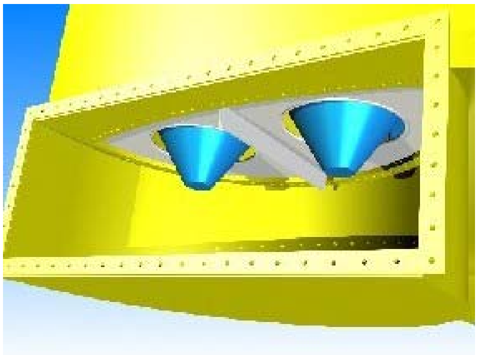
Modern design tools

The dart plug valve has also evolved to its current form through the use of technically pioneering tools, such as computational flow dynamics (CFD) and has undergone years of vigorous testing in both lab and on site. The current model of a dart plug valve has a curved profile to optimize the flow control characteristics. Compare this to dart plugs from even 10 years ago, where 500mm was considered large and the plug was simply a squat, basic, straight-sided "bath plug".

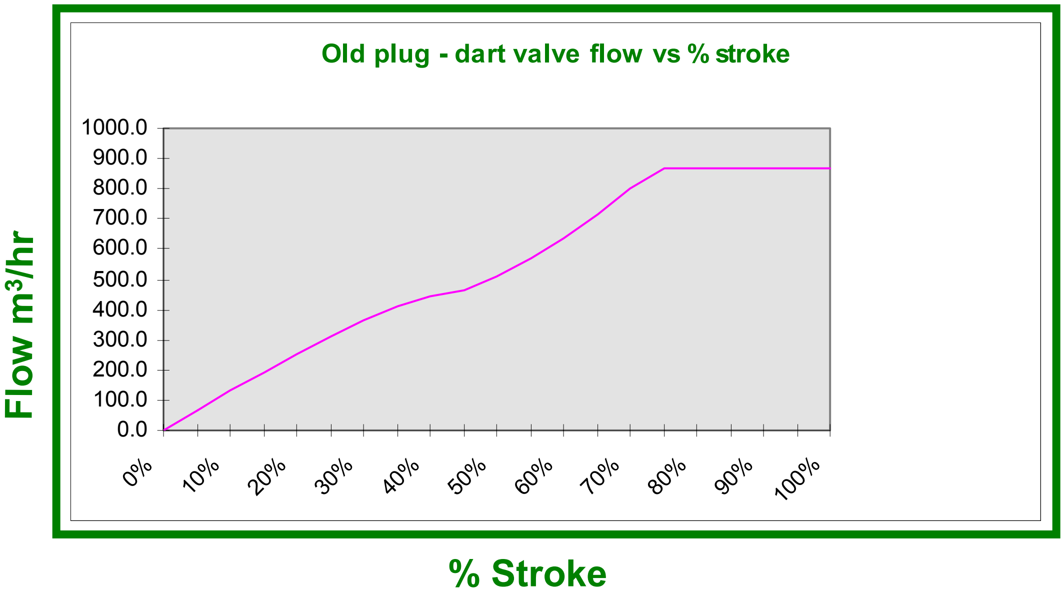
Thanks to 'modern' tools such as finite element analysis (FEA) and CFD – a great deal more is also understood in flotation in terms of optimizing slurry flow. The shape and depth of the modern dart

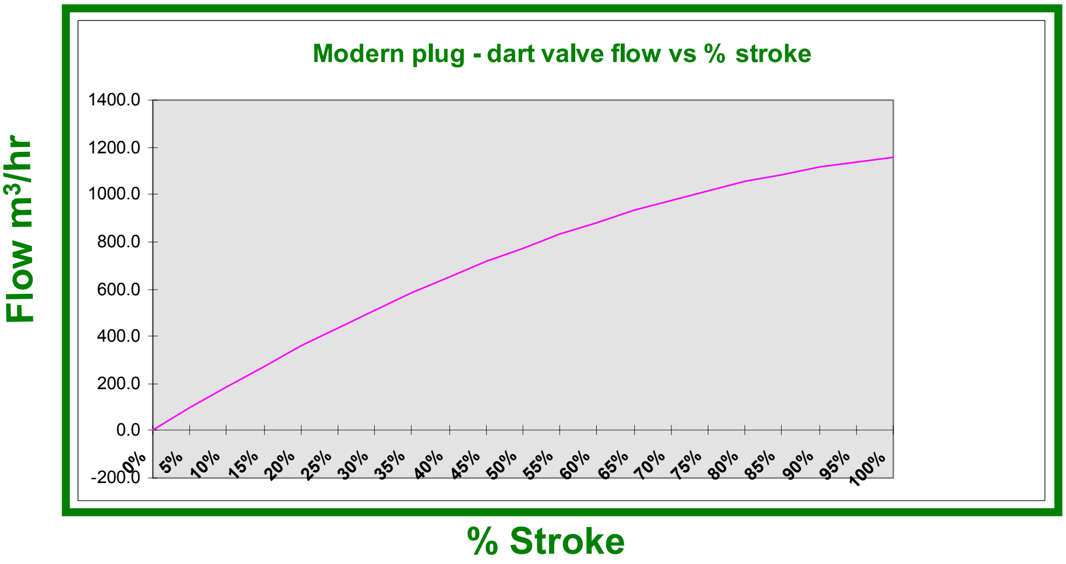


Curved profile



Straight profile





plug, for example, are critical to its performance as a flow control valve. The two above curves represent the improvement that has been achieved in recent years through redesigning of the valve shape and matching its flow profile to the stroke length of the pneumatic cylinder.

You can see that the flatter, older squat “bath plug” style has a fast initial response but soon reaches its maximum flow and then the curve flattens and there is no further increase in flow through the valve. This issue is resolved in the modern plug by increasing the depth of the plug so that it is responsive over the full range of the pneumatic cylinder. Some modern plugs also have curved sides to create a more linear response which improves the valve’s flow control characteristics, as demonstrated in the above chart.

Additional challenges

The development of larger valves to meet ever-increasing plant throughputs has presented additional challenges such as the selection of the positioner, response time of the pneumatic cylinder, structural strength of the valve – including the valve stem and bearings. In many cases, the installation of speed relays are required to maintain the valve response time as the positioner cannot discharge the exhausted air from these large cylinders fast enough. If this situation occurs without speed relays, the PID control loops will indicate that the valve is 'hunting' as the valve is physically constrained. Hence, the outcome will be poor level control and erratic concentrate production, which will impact negatively on flotation recovery if not corrected.

Optimising the design

The structural integrity of the valve is ensured nowadays through the use of stainless steel inserts within the moulded polyurethane plug. Prior to this innovation, the plugs were moulded simply from polyurethane.

Straight profile – steel inserts

Curved profile – steel inserts

Nowadays, apart from the stainless steel inserts, the skeleton includes a universal stub flange, which allows for fast and easy replacement of the dart plug during maintenance. The stub flange design also allows the plug size to be changed easily as the new plug size is cast with the standard stub flange fitted and thus bolts directly to the existing dart valve shaft. The positioning of the bottom bearing and flow deflectors are carefully calculated to eliminate shaft vibration and ensure the smooth operation of the dart valve through its entire stroke.

Going down for high velocity pulp

The dart plug itself is not the only aspect of the dart valve system which has changed in recent years. The way in which dart plugs are incorporated into the flotation cell layout is also evolving. Not so long ago, the use of upflow dart valves in a flotation circuit meant a separate external dart box in the cell layout. This involved additional layout space and capital cost. These boxes also had a tendency to build up and overflow the froth in plants where stable froth characteristics were otherwise exhibited. The upflow dart valves were also the cause of many sanding problems within the cell. Unfortunately, the cell mechanism was often blamed, when in fact the problem was due to the low pulp velocity through the dartbox and the fact that coarse particles could not get out of the cell. In 1995, downflow darts were designed and introduced by Outokumpu Technology – thereby offering a solution to this type of scenario.

Internal valves make sense

The modern plant layout is also more likely to see the dart valves incorporated into the cell itself. This removes the need for an expensive external box, eliminates sanding, minimizes the plant footprint and removes any possibility of the froth overflowing onto the plant floor. From an OH&S perspective, access to the dart valve is much easier from inside the cell. These days, for example, Outokumpu Technology's large TankCells® also have inspection doors which makes confined-space-work safer, plus it is much easier to carry out planned maintenance checks.

Intermediate dart boxes

In the past, intermediate dartboxes were also used for the addition of flotation reagents and for the accommodation of return process flows. Today, reagent additions can be made to each TankCell® via the froth booster cone. Return flows from the process can also be added to the froth booster cone or through a specially designed in-cell pipe.

Conclusion

Dart valves have come a long way in recent years. In order to ensure a float circuit is performing at optimal level, the valve system should have the following features:

- A profile and depth which are matched to the pneumatic cylinder and provide a near-linear response over the full flow range
- A strong moulded construction designed for rapid changeover during maintenance
- A rapid-response pneumatic cylinder for larger valves
- A float cell configuration which is designed with minimal impact to the foot print and capital cost of the plant.

Ensuring your technology provider has incorporated these features in your dart valve system will provide for years of accurate flow control with minimal maintenance.

Peter Bourke is Global Technology Manager - Flotation Process, for Outokumpu Technology. Peter has extensive knowledge of the mining industry, with over 30 years experience in mining and flotation. During his career, Peter has worked in a variety of roles including senior metallurgist, plant superintendent and mine manager in both Australia and overseas. He has been with Outokumpu Technology since 1991 and has played a major role in the development of the company's flotation technologies.

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