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Process Risk Management in Mineral Processing Projects – A Better Way

Author: Andrew Okely

Mining equities are generally considered amongst the most risky investments available on the Australian Stock Exchange. With the exception of short-lived excursions such as the tech boom (and subsequent bust) this has generally been true in the last decade or so. This riskiness is not in itself a bad thing as long as the returns are high enough to compensate for the extra risk. Sadly, only half of the risk/reward equation has been true for mining equities in recent times. The risk (as measured by the standard deviation of annual returns) has recently been much higher than that of the overall market, however the return has been substantially lower. *See Table 1.*

	Annual Return	
Year	All Ords Index	All Mining Index
1993	51.2%	76.3%
1994	-20.8%	-9.9%
1995	25.0%	12.3%
1996	5.9%	-2.6%
1997	9.6%	-34.9%
1998	8.9%	0.7%
1999	7.0%	32.4%
2000	6.3%	-9.9%
2001	3.4%	15.4%
Average (Return)	**10.7%**	**8.9%**
Std Deviation (Risk)	**19.2%**	**31.6%**

Table 1. Annual returns for All ordinaries v's All mining indices 1993-2001.

Graphically the situation is even more dramatic, $1000 invested in the mining index in Jan 1993 would have been worth $1566 in January 2002 whilst the same amount invested in the all ordinaries index would have grown to $2227. *See Figure 1.*

Interesting, but what does this have to do with today's plant designers and operators? Actually everything. The result of long-term poor performance is a lack of funding for the industry in this country. Reduced funding for exploration, mine development and most critically for industry development (R&D, university support and industry promotion). Shareholders want a reasonable, risk adjusted return and companies have to cut exploration, R&D and development of the intellectual pool to try and achieve those returns.

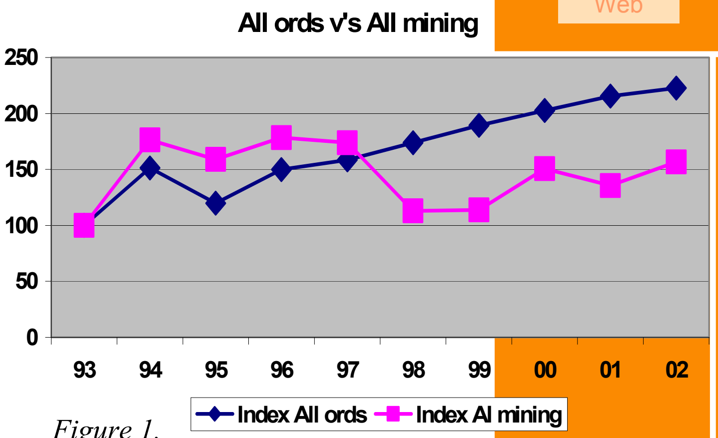

Figure 1.

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One of the causes of this poor share market performance has been the steady stream of disasters. I won't mention any names here but we can all think of numerous projects that failed. Many of these projects fail because the process objectives cannot be achieved i.e. the Process Risk was not adequately identified and managed. The question is why, in this time of "knowledge", with resources such as cooperative research projects and computer modeling, does this continue to happen on a regular basis? In many cases the technologies involved have been used for decades. Is it possible that the method used to develop projects is itself flawed?

Current Practice:

Of course it is always dangerous to generalise, however it could be said that the present method of developing a project is for the owner to find a suitably qualified head contractor who takes overall responsibility for design and construction of the project. This contractor then subcontracts the various components of the project to others. The head contractor generally provides some form of process guarantee based upon the development test work and an assessment of the process risk. The various elements of this guarantee are then passed on to carefully selected, industry leading subcontractors.

In theory this spreads the risk. In practice, if the project fails, the owners, be they debt or equity providers lose most, if not all of their money, which in reality could never be replaced by the various subcontractors or head contractor.

So even with a strong contractual structure and careful selection of quality technology suppliers, we still see a project failure that is unacceptable. What many fail to realise is that the risk assessment and process guarantees are really people's best guesses, based upon the available data and past experience which generally raises more questions than answers.

If the people or organisations involved are not the problem, then maybe we do not have enough good quality data. The nature of mineral processing is such that there will always be gaps in the data from which we design plants. These gaps are invariably filled by a combination of experience, judgment and measured risk taking. The result of these activities is a process flow sheet and design criteria. Once established by the head contractor, these design criteria are used to size and select the necessary equipment.

If we look at a typical design criterion for a rougher flotation circuit we can begin to see where the problems start.

	Min	Design	Max
Flow T/hr	100	120	150
%Solids w/w	25	28	30
%/Cu. Feed	1.1	1.4	1.6
%Cu Con.	18	20	22

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The actual operating window required looks like this:

	Min	Design	Max
Flow T/hr	100	120	150
%Solids w/w	28	35	25
%/Cu. Feed	1.6	1.4	1.1
%Cu Con.	22	20	18

The reason for the difference turns out to be changes in ore type as the mine life progresses. The different throughput rates come from the desire to maintain production of Cu in concentrate at the same level throughout the life of the project. The lower %Solids in the maximum throughput case is selected to cope with the change in ore type associated with the change in feed grade. The slurry was more viscous with the lower Cu grades in this case.

Clearly a flotation cell designer will get the cell selection wrong using the provided design criteria if he or she is unaware of the actual operating requirements.

A Better Way.

We must begin to work from the basis of common knowledge. Obviously a better understanding of the way design criteria is generated by the flotation cell designer is a good start. Equally useful is a greater understanding of how flotation cells are actually designed by the engineer. We can then think about the larger project picture. When does the treatment rate change, will the grind change and how does the froth behave as the ore changes, are all questions a flotation cell designer would start to ask. The engineer and owner might look at issues such as the range of throughputs, both slurry and contained metal, that a technology can accommodate.

What is described here is different people working in partnership with the same objective, a better return on investment from our mineral projects. But how do we maintain competition? This is clearly a challenge. I propose a two pronged attack on this problem.

Firstly we must start to educate each other more. This should become ongoing and be implemented outside the heat of the contract.

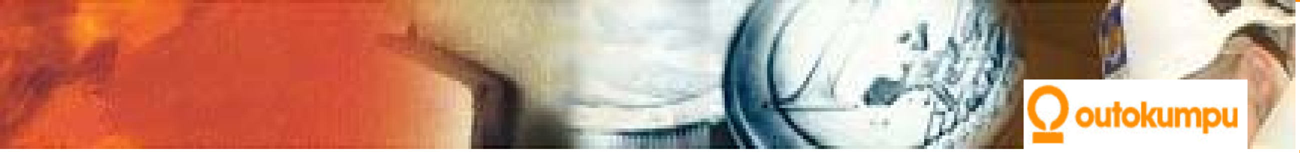
Having achieved a greater level of shared understanding a more open dialogue will allow the "competitive" criteria to move away from the unit process and focus on the project. What will add value to the project overall? The answer to this is always different and project specific. Thus different organizations can compete on the basis of what adds the most value to the project rather than who can supply a predetermined and potentially less optimal solution at the lowest price.

A number of pricing methodologies are possible, all of which depend upon an increased level of trust. Concepts such as:

- Open Book/Closed Book
- Escalation of previous contract values
- Total installed cost
- Total cost of ownership

are all avenues which can be used to explore the competitiveness of any given contract.

The prize for us all is not only a healthier local industry but also a true competitive advantage offshore. Australian mining companies can develop better projects in other countries supported by an engineering and technology supplier industry that is robust, flexible and smart. The alternative is a shrinking mining sector which cannot support local engineering and technology industries. We would then have to buy engineering know how and process technologies off shore and wait for support from overseas, which would probably not be forthcoming.



VACUUM BELT FILTERS – BETTER THAN EVER.

Author: Venkatesh Viswanathan

There are two main technologies available for vacuum filtration: Vacuum disc (with and without filter cloths) and Horizontal Vacuum Belt Filters. The latter of these two is the subject of this article, which will identify some of the shortcomings of the present vacuum belt filter technology and describe a new approach.

Horizontal Belt Filters can be found in two key application areas:

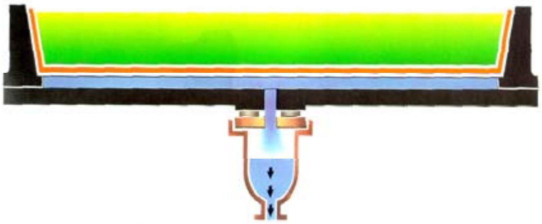
1. Filtration of mineral slurries with a P80 of greater than 50um (e.g.fine coal, dewatering).
2. Slurry streams where cake washing is required (e.g. hydrometallurgical processes).

In both of these situations the hydraulic capacity of the filter is critical to the throughput and, where applicable wash performance. Present vacuum belt filter technologies generally rely on a rubber belt to support the filter cloth and facilitate transport of the filtrate to the vacuum box. The vacuum box is located in the centre of the belt.

Limitations to the Present Configuration Filter Belt.

One of the critical factors which limits the performance of Vacuum Belt Filters is the design of the rubber belt. The belts are manufactured with holes in them to allow flow of the filtrate to the vacuum box. The size of these holes governs the rate at which filtrate is removed.

The filter belt must also have sufficient mechanical strength to support the filter cake. The presence of the filtrate holes reduces mechanical strength and results in the need for greater belt thickness. Thus present rubber belts are thicker than desired yet still restrict filtrate removal.



Filtrate Box

The location of the vacuum box in the centre of the frame also creates two additional design limitations.

1. The filtrate streams coming from the two halves of the belt need to make a 90° turn to enter the vacuum box. This creates a turbulent zone which can create a crystallization point in cake washing applications. This area requires increased cleaning and maintenance.
2. Locating the vacuum box below the centre of the filter belt makes access for maintenance difficult. The gap between the upper and lower belts is greater resulting in longer pulleys and increased installation.

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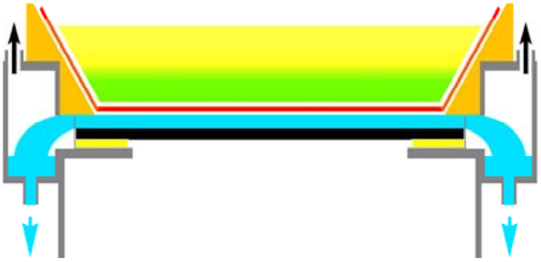
A Better Future:

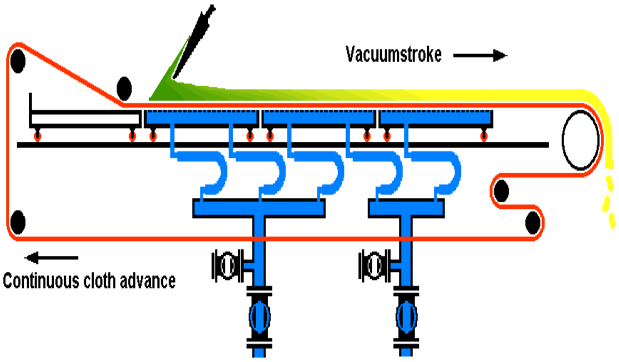
The vacuum belt filter of the future would ideally remove the need for filtrate holes in the rubber belt, and thus the hydraulic limitation this creates.

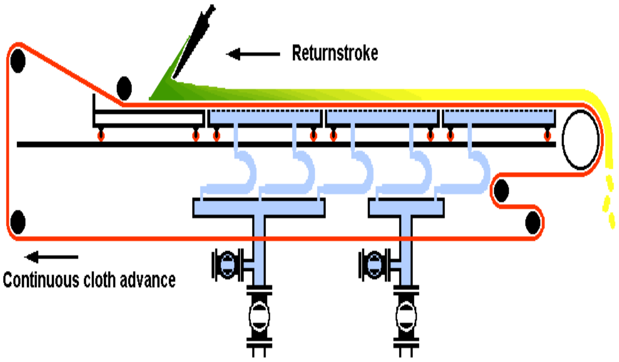
A lighter, thinner, belt with surface grooves for filtrate transport to side vacuum boxes provides the solution. The hydraulic capacity is increased, whilst belt drive pulleys diameter and power consumption are reduced. This new belt design/side vacuum box combination allows a more efficient, compact and maintenance friendly machine. The filtrate flow into these unique side vacuum boxes is smooth and lamellar which greatly reduces salt precipitation in filter cake washing applications.



Another design possibility is the removal of the rubber belt completely. The filter cloth is supported by an open grid tray system. The cloth and trays move together whilst the vacuum is applied until the trays reach the end of the filter.

The vacuum is then briefly cut and the trays return to the head end of the filter. This unique concept can effectively combine multiple filtering steps into one. Each tray can collect a separate filtrate stream making multi-stage counter current washing of filter cake to produce a clean cake and pregnant liquor possible on one machine.





Vacuum belt filters are now better designed for mineral processing applications. They have greater hydraulic capacity, reduced installation envelopes and offer more effective cake washing solutions than ever before. All of these features make them a technology that should be considered in many dewatering situations.

SAMPLE PIPING SYSTEMS ➔ DO's & DON'Ts

Author: Christian Alfthan

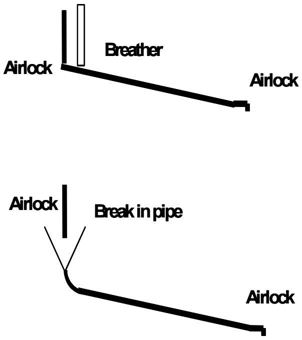
The modem concentrator has the potential to contain many sophisticated process control tools. One thing all of these tools have in common, is the need for a sample and analyzer system to provide input and feedback. Such a system consists of three elements – samplers, sample transport and sample analysis. This article will provide some practical tips for getting the sample transport correct.

There are two generic types of sampling systems, those using pressure and those flowing via gravity. The piping design requirements for each, do differ.

Gravity Sample Piping

The key to successful gravity flow sample piping is keeping a free path for air at all times. If the pipe does fill with slurry, it will either act as a constant pressure line delivering too much sample to the analyser or, worse still, may oscillate between gravity and pressure flow which creates flow surging.

Air locks are responsible for creating pressure flow conditions in a gravity pipe system. Unfortunately airlocks can occur for a number of reasons and with relative ease. Fortunately one airlock in a pipe will not create a pressure flow situation. Problems only begin when two airlocks occur in the same pipe run. Breathers are the most common solution to airlock problems. Two examples of breather systems can be seen in the following illustration (above).



Breathers are used between two airlocks to prevent pressure flow

It is important to ensure that Breathers are larger than the slurry pipe they are servicing.

Airlocks can occur for many reasons, the most common of which are:

- Sharp "knee" type bends in piping
- Gravity sampler is full of slurry
- Horizontal sections in piping
- Internal pipe connections restrict flow
- Deliberate flow brakes

Pressure Sample Piping

Pressure sample piping presents a different set of challenges to those faced when using gravity systems. The main potential problems in this case are:

1. Loss of Siphon pressure creating a gravity line rather than a pressure line
2. Solids landslides blocking pipes
3. Pipe systems that are too long for the available head.

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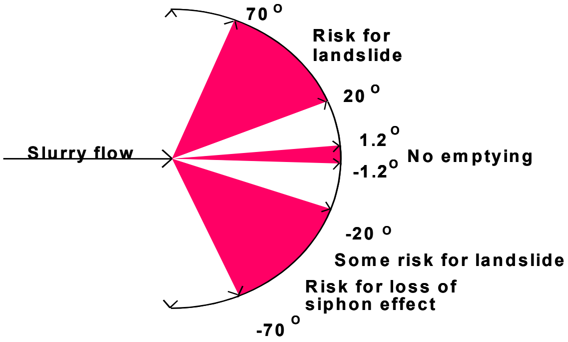
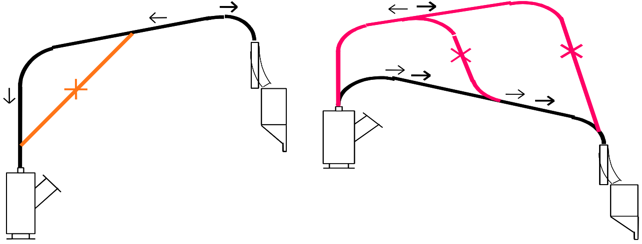
The first two items are managed by managing the slope of the pipe. Angles between +20^0 and –20^0 are recommended to avoid landslide and siphoning problems.

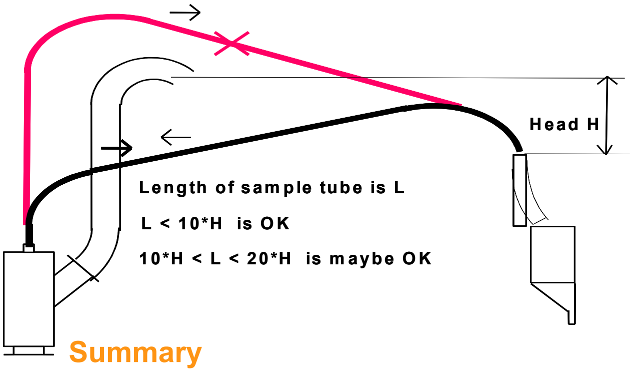


Landslide effects are generally not seen until the slurry flow stops. Horizontal pipe sections should also be avoided as they will not drain when the line is shutdown. Two examples of pipe routing are as follows.



Maintaining a balance between the available driving head and sample pipe length is important for trouble free sample collection.

A good rule of thumb is to keep the length of pipe to less than 10 times the available driving head. Pipe lengths between 10 and 20 times should be double checked via calculation for pressure losses. Pipe lengths greater than 20 times should be avoided wherever possible. The Diameter of the pipe should always be calculated to give a flow suitable for the analyzer. The diagram below illustrates the way in which the minimum driving head should be calculated.



Summary

The design of sample piping, which will provide years of trouble free operation, takes thought and planning and must be considered during the plant design. Systems added after the plant is built will generally require substantial operator maintenance. Most importantly critical process control samples may not be available when needed if sample piping is continually blocking.

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