

Tailings filtration: risk reduction through understanding and designing for variability

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Abstract

In the face of recent high-profile tailings dam failures there has been an increased focus on the consideration of tailings filtration and dry stacking systems as an alternative to conventional or thickened discharge-based tailings management systems. However, whilst the potential benefits of a filtered tailings system can be significant, for instance in terms of water efficiency and reduced geotechnical risk, the high capital cost of such systems means that significant process or environmental drivers must typically exist to justify the expense. Furthermore, whilst larger-scale filtered tailings installations are now being successfully operated, such as in the alumina industry, there have also been operations that encountered significant problems leading to the tailings management system constraining overall plant productivity.

In view of the significant capital investment required to implement a filtered tailings management system, understanding and mitigating key factors that could lead to tailings processing bottlenecks is therefore a critical part of the technical review of any proposed filtration and dry stacking system. In particular, the ability of the system to cope with potential variation in upstream process conditions or tailings material properties, or the risks associated with unanticipated such variation need careful consideration. However, sometimes the impacts of such variation are not clear from what is often relatively limited filter design testwork conducted on a limited range of samples, or the risks are not evident without taking a broader perspective beyond the filter plant alone.

This paper illustrates, with the aid of model-based filtration simulations, examples of the nature and magnitude of typical system impacts due to factors such as variability in thickener underflow solids concentration and tailings dewaterability properties (whether due to variable plant feed or unexpected process conditions). System impacts discussed are not limited to high-level performance indicators such as filter throughput and cake solids concentrations, but will also consider filter design choice, filter operability, maintenance and downstream materials handling. Strategies for mitigation of these risks are also discussed. Whilst this work focused on membrane plate filters, the principles discussed are equally relevant to fixed cavity presses (and indeed other filter designs) and can assist in the design-making process of which type of filter best meets the needs of a given application.

Keywords: *pressure filtration, process risk, feed solids concentration, optimisation, modelling*

1 Introduction

Over the past decade there has been a growing interest in the implementation of large-scale filtered and dry stacked tailings operations. This has particularly been in response to several high-profile tailings dam failures in recent years, but also due to the development of larger pressure filters with a lower cost per unit filter area making the technology more cost competitive. The potential benefits of a filtered tailings system as an alternative to conventional or thickened discharge-based tailings management systems can be significant, for instance in terms of water efficiency and reduced geotechnical risk. However, even with improved economics, filtration systems still carry a comparatively high capital cost relative to alternatives, and significant process or environmental drivers must typically exist to justify the expense (Davies 2011).

The relatively recent commissioning of projects such as the Karara magnetite tailings (35,000 tpd) and Kwinana red mud (6,000 tpd) filtration and dry stacking plants, and several planned projects in alumina and nickel laterite processing has demonstrated a willingness in industry to embrace this technology at larger

scales. However, there have also been instances where significant problems with the filter plant lead to the tailings management system constraining overall plant productivity with serious economic ramifications (Hore & Luppnow 2014), which highlight the potential process risks with the approach.

In view of the significant capital investment required to implement a filtered tailings management system, understanding and mitigating key factors that could lead to tailings processing bottlenecks is therefore a critical part of the technical review of any proposed filtration and dry stacking system.

The ability of the system to cope with potential variation in upstream process conditions or tailings material properties, or the risks associated with unanticipated such variation need careful consideration. In most operations, some level of tailings variability will be inevitable due to ore type variation, whether planned or unplanned, or upstream process changes leading to particle size or process chemistry changes. The net effect of such changes can be significant variation in the dewaterability properties of the filter feed, and/or the required tailings processing duty. However, sometimes the impacts of such variation are not clear from what is often relatively limited filter design testwork conducted on a limited range of samples, or the risks are not evident without taking a broader perspective beyond the filter plant alone, for example, considering the variability in upstream operations such as thickening and tailings transfer, on which filter performance is directly dependent.

Simulation tools, such as that used in this work, and the more general dewatering material property information required for their utilisation can be highly informative in assessing the impact of process changes on filter performance and optimising plant design. Typical equipment vendor filtration testing is conducted in a manner that assesses the process outcome for a discrete number of process scenarios (e.g. pumping, pressing, air blow duration, chamber thickness, feed solids concentration) and the results of these tests are of limited use in assessing filter behaviour beyond the operational conditions actually tested. However, combining characterisation of the underlying material property data (filter cake resistance and cake solids concentration as a function of applied pressure) with a suitable modelling tool provides much greater scope to assess filter performance for any operational condition or filter cycle configuration and guide the process of design optimisation.

There is certainly no substitute for traditional filter vendor testwork in selecting and sizing a filter design. However, in view of the highly variable testing approaches and level of reporting detail from vendor to vendor, and even between different test engineers within a company, independent characterisation of dewatering material property data and its use in model-based assessment can significantly de-risk the process of filter design assessment, and provide clarity in comparing proposed filter sizings from different vendors.

This paper outlines, with the aid of model-based filtration simulations, examples of the nature and magnitude of system impacts due to factors such as variability in thickener underflow or tailings transfer solids concentrations and tailings property variability (whether due to variable plant feed or unexpected process conditions). The filtration simulations are based on material properties and conceptual membrane filter press design indicative of a red mud pressure filtration system. System impacts discussed are not limited to high-level performance indicators such as filter throughput and cake solids concentrations, but will also consider filter operability, maintenance and downstream materials handling. Strategies for mitigation of these risks are also discussed. Note that whilst this work focused on membrane plate filters, the principles discussed are equally relevant to fixed cavity presses (and indeed other filter designs) and can actually assist in the design-making process of which type of filter best meets the needs of a given application.

2 Methodology

Model-based membrane pressure filter simulations were conducted using a modified version of an empirical pressure filter model available in the literature (de Kretser et al. 2010; de Kretser & Scales 2011). The model determines the primary filtration time and secondary filtration times associated with deposition of a user defined range of target cake thicknesses prior to final cake compression to achieve a dewatered cake. Primary filtration is defined as the process of cake formation that occurs as material is being fed into the filter under pressure during the filling or pumping stage. In many cases, pumping is stopped before cake growth spans

the filter cavity, and in this case at the time when pressing commences, residual slurry exists within the filter chamber. Secondary filtration is defined as the process of filtration of this residual slurry during the initial stages of pressing. A schematic of primary and secondary filtration is presented in Figure 1.

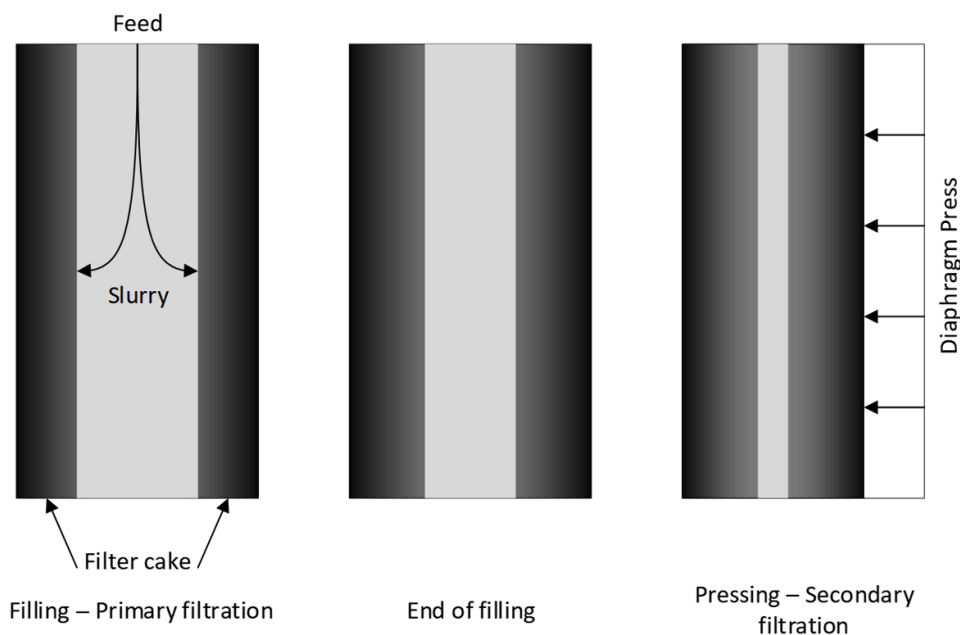


Figure 1 Schematic illustrating the difference between primary filtration during the filling stage and secondary filtration which occurs during the initial stages of the pressing stage

The model only describes the filtration/cake formation behaviour and does not have functionality to predict the actual time required for cake compression. Therefore, a representative cake pressing time needs to be manually entered, however, as will be described later, the simulation results can be used to assess whether this pressing time is appropriate, or is likely to be insufficient to achieve a fully compressed cake.

The model requires the following material property data at the desired feeding and pressing pressures:

- Cake formation and equilibrium compressed cake solids concentrations.
- Filter cake resistance (typically as a specific cake resistance).

The above data are readily determined from the wide range of standard laboratory filtration test methods that can be found in the literature (e.g. Wakeman & Tarleton 1999).

The model simulations presented in this work are for a conceptual pressure filtration of a red mud tailings slurry in a membrane filter press. A baseline design case was first assessed, for which dewaterability material property data in the form of specific cake resistance and cake solids concentration versus pressure was selected that was indicative of a typical red mud slurry, based on the author's professional experience.

To assess the impact of the processing of a problematic ore type with poorer dewatering characteristics, for example due to a finer particle size, a worst case set of dewaterability material property data was developed. This involved scaling the specific cake resistance and cake solids concentration versus pressure data used for the baseline case based on levels of variability seen in practice in the author's professional experience. Specifically, the changes made for the worst case scenario were:

- The specific cake resistance was approximately double that of the baseline case at the filtration and pressing pressures.
- Filter cake solids concentrations were of order 4% w/w lower than those of the baseline case at the filtration and pressing pressures.

In addition to direct impact of the poorer dewaterability properties on filter operation, it was desired to assess the potential secondary impact on filter performance from an inability to thicken and/or pump the red mud as effectively, resulting in a lower filter feed solids concentration. Based on the author's experience, a poorer dewatering red mud could exhibit shear yield stresses comparable to the baseline case at solids concentrations 5% w/w lower. This was used to provide a guide for the potential level of reduction in filter feed solids concentration due to poorer thickening performance.

The modelling exercise was conducted to assess the following scenarios:

- A base case scenario was modelled for the pressure filtration of the baseline case red mud at a filter feed solids concentration of 50% w/w. The conceptual filter press design for this base case is described in Table 1. The press loading time required to fill the filter chambers with slurry, and the technical times associated with operations such as press opening and closing listed in Table 1 are based on typical industry values.
- Low feed solids concentration scenarios were assessed for the baseline case red mud at filter feed solids concentrations of 45 and 40% w/w solids.
- A poor filterability feed scenario was modelled for the worst case red mud, but still at a solids concentration of 50% w/w solids.
- A worst case scenario was modelled for the worst case red mud, assuming a reduction in filter feed solids concentration to 45% w/w solids due to poorer thickening performance.

Table 1 Details of conceptual filter press design used in model simulations

Parameter	Value
Cavity thickness	35 mm
Cavity design	Double sided, membrane plate
Press loading time	60 s
Design fill/pumping time	250 s
Fill/pumping pressure	600 kPa
Design pressing time	300 s
Pressing pressure	1,000 kPa
Technical time	300 s

In each case the simulation results were assessed in terms of the following:

- The required fill/pumping duration to deliver sufficient solids into the filter chambers to reduce the risk of pressing diaphragm damage due to excessively thin cakes.
- The required fill/pumping and pressing durations required to reduce the risk of discharge of wet cake due to insufficient pressing.

The resultant filter throughput for filter cycle stage configurations that met the above operational constraints was then determined.

3 Results

3.1 Baseline case at design feed solids concentration of 50% w/w

Modelling results for the baseline case red mud with a 50% w/w solids filter feed are presented in Table 2. The results are presented as a function of filling/pumping duration with the conceptual filter design profile, with a fill duration of around 250 seconds, highlighted. The results illustrate typical behaviour in that the thicker cake deposited after longer filling durations leads to a reduction in the time required for secondary filtration during the pressing stage. In the case of a filling duration of zero seconds, which effectively means that feeding of the press is stopped as soon as the cavities are filled with slurry, 199 seconds of the 300 second pressing stage will be associated with the process of secondary filtration, rather than actual active cake compaction. This raises the operational risk that insufficient cake compaction time is available to achieve a fully dewatered cake. Ensuring that the percentage of the press stage available for active pressing, as listed in Table 2, is above a threshold level is therefore useful in avoiding operational risk.

The actual acceptable minimum threshold percentage for active pressing will depend on the material properties of the substrate in question. In the case of this modelling exercise, active pressing percentages below 50% have arbitrarily been considered unacceptable. Most significant in the context of this conceptual exercise is how this parameter changes in response to variations in process conditions.

The second operational indicator presented in Table 2 is the percentage cavity utilisation, which quantifies the percentage of the filter cavity that is filled with cake at the end of cake pressing. For many filter plate designs, low cavity utilisations (i.e. thin cakes) can result in over-inflation of the pressing diaphragm leading to damage or reduced operational lifespans. The minimum cavity utilisation will be highly filter design-specific, and there are some filter plate designs that can operate at very low utilisations. However, for this exercise, a cavity utilisation below around 65% has been considered unacceptable.

Table 2 Baseline case red mud – 50% w/w feed solids: Filter press modelling results as a function of fill stage duration. Conceptual design filter cycle profile indicated by cross-hatching. Orange shading indicates operational risk (35 mm cavity, press loading adjustment = 60 s, technical time = 300 s)

Fill/ pumping (s)	Cake deposited after fill (m)	Press (s)	Secondary filtration time (s)	Total cycle duration (s)	Final cake thickness (m)	Cavity utilisation (%)	Active pressing (%)	Throughput (kg/m ² hr)
0	0.0000	300	199	660	0.0221	63.1	33.5	71.4
110	0.0150	300	187	770	0.0262	75	37.7	72.7
174	0.0200	300	164	834	0.0276	78.9	45.4	70.6
252	0.0250	300	131	912	0.0290	82.9	56.4	67.8
344	0.0300	300	88	1,004	0.0304	86.8	70.5	64.6
449	0.0350	300	36	1,109	0.0318	90.8	87.9	61.1

In terms of filter throughput, the data in Table 2 suggests that higher throughputs could be achieved with shorter filling durations, however, this would result in thin cakes and low levels of active pressing time. As such, the cavity utilisation and active pressing constraints practically limit the achievable filter throughput and the conceptual filter design profile has a throughput that is slightly lower than the optimum.

3.2 Baseline case at reduced feed solids concentration

Modelling results for the baseline case red mud with 45 and 40% w/w solids filter feed are presented in Tables 3 and 4 respectively.

The modelling results for the 45% w/w solids feed case (Table 3) illustrate that as the feed concentration is reduced, less cake is deposited per unit time during the filling stage as the hydraulic load per unit mass of cake in the filter is increased. This results in the conceptual design filter cycle no longer meeting the active pressing constraint, as well as a significant reduction in overall filter throughput compared with the 50% w/w feed condition.

To satisfy the active pressing constraint two non-exclusive approaches are possible:

- The fill stage duration can be increased so that more solids are loaded into the press and secondary filtration times are reduced. Table 3 suggests that a 338 second fill duration would satisfy this condition.
- Alternatively, the press stage duration could be increased to increase the active pressing percentage above the threshold level. Table 3 presents an adjusted filter cycle where the press stage duration was increased to 390 seconds.

The net effect of either of these changes is to lengthen the filter cycle and further reduce the filter throughput by around 15% from the design throughput.

Table 3 Baseline case red mud – 45% w/w feed solids: Filter press modelling results as a function of fill stage duration. Conceptual design filter cycle profile indicated by cross-hatching. Orange shading indicates operational risk (35 mm cavity, press loading adjustment = 60 s, technical time = 300 s)

Fill/ pumping (s)	Cake deposited after fill (m)	Press (s)	Secondary filtration time (s)	Total cycle duration (s)	Final cake thickness (m)	Cavity utilisation (%)	Active pressing (%)	Throughput (kg/m ² hr)
0	0.0000	300	214	660	0.019	54.3	28.8	61.4
150	0.0150	300	209	810	0.024	69	30.5	63.6
235	0.0200	300	184	895	0.026	73.9	38.7	61.6
338	0.0250	300	147	998	0.028	78.8	50.8	58.9
459	0.0300	300	100	1,119	0.029	83.7	66.8	55.8
598	0.0350	300	40	1,258	0.031	88.6	86.6	52.5
Adjusted cycle to meet cavity and pressing constraints								
235	0.0200	390	184	985	0.026	73.9	52.9	56

Table 4 Baseline case red mud – 40% w/w feed solids: Filter press modelling results as a function of fill stage duration. Conceptual design filter cycle profile indicated by cross-hatching. Orange shading indicates operational risk (35 mm cavity, press loading adjustment = 60 s, technical time = 300 s)

Fill/ pumping (s)	Cake deposited after fill (m)	Press (s)	Secondary filtration time (s)	Total cycle duration (s)	Final cake thickness (m)	Cavity utilisation (%)	Active pressing (%)	Throughput (kg/m ² hr)
0	0.0000	300	219	660	0.016	46.2	26.9	52.2
248	0.0175	300	212	908	0.023	66.4	29.2	54.5
369	0.0225	300	181	1,029	0.025	72.1	39.7	52.3
511	0.0275	300	136	1,171	0.027	77.9	54.5	49.6
676	0.0325	300	79	1,336	0.029	83.7	73.8	46.7
862	0.0375	300	8	1,522	0.031	89.4	97.4	43.8
Adjusted cycle to meet cavity and pressing constraints								
369	0.0225	390	181	1,119	0.025	72.1	53.6	48.1

The modelling results for the 40% w/w solids feed case presented in Table 4 illustrate the same features of reduced throughput and violation of the active pressing constraint as was discussed in relation to the 45% w/w feed solids case. This is again due to the greater hydraulic load per unit mass of cake for the more dilute feed. To satisfy the active pressing constraint the data in Table 4 suggests a doubling of the filling stage duration to around 500 seconds. The filling duration could alternatively be kept at around 250 seconds and the press stage duration increased, however, the cavity utilisation for this fill duration is close to the minimum threshold. Therefore, the alternative adjusted cycle presented in Table 4 utilises a combination of a longer fill and longer pressing stage.

Importantly, irrespective of which mitigating approach is adopted, the net effect of either is again a further reduction in the filter throughput to a level around 30% lower than the design throughput.

The data in Tables 3 and 4 highlights the significant impact that reduced feed solids concentration has on filter throughput. The filter throughputs for adjusted filter cycle profiles that satisfy the cavity utilisation and active pressing constraints are plotted against feed solids concentration in Figure 2, which illustrates that a 10% w/w reduction in feed solids concentration can result in a 30% reduction in filter throughput. This highlights the importance in making realistic design assumptions around what feed solids concentration can be reliably delivered to a filter plant and whether this may be affected by factors such as achievable thickener underflow solids concentration or the ability to transport tailings at the required solids concentration. Furthermore, data of this type provides an indication of the sensitivity of the filter plant operation to upstream variations which can then inform the processes of design optimisation and process risk mitigation.

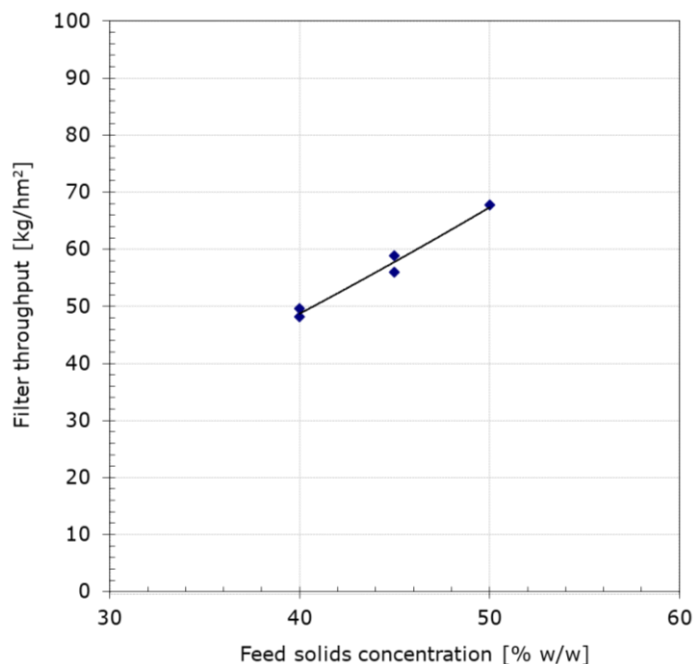


Figure 2 Filter throughput for baseline red mud as a function of filter feed solids concentration

3.3 Worst case red mud at design feed solids concentration of 50% w/w

Modelling results for the worst case red mud at the design 50% w/w solids filter feed are presented in Table 5. These results illustrate that the high cake resistance (lower permeability) of the worst case red mud reduce the cake formation rates, with a reduction in filter throughputs compared to the baseline case (in Table 2). Due to the slower rate of cake formation, the conceptual design filter cycle no longer meets the active pressing constraint. To satisfy the active pressing constraint, the data in Table 5 suggests close to a doubling of the filling stage duration to around 500 seconds or, alternatively, the filling duration could be kept at around 250 seconds and the press stage duration increased to 420 seconds. The net effect of either of these changes is a lengthened filter cycle and reduced filter throughput of between 53 and 55 kg/hm² (around a 20% reduction from the 68 kg/hm² for the design case).

Table 5 Worst case red mud – 50% w/w feed solids: Filter press modelling results as a function of fill stage duration. Conceptual design filter cycle profile indicated by cross-hatching. Orange shading indicates operational risk (35 mm cavity, press loading adjustment = 60 s, technical time = 300 s)

Fill/pumping (s)	Cake deposited after fill (m)	Press (s)	Secondary filtration time (s)	Total cycle duration (s)	Final cake thickness (m)	Cavity utilisation (%)	Active pressing (%)	Throughput (kg/m ² hr)
0	0.0000	300	290	660	0.025	70.6	3.4	71.4
122	0.0075	300	274	782	0.028	80	8.6	68.3
202	0.0100	300	241	862	0.029	83.2	19.8	64.4
249	0.0113	300	218	909	0.030	84.7	27.2	62.2
359	0.0138	300	163	1,019	0.031	87.9	45.5	57.6
488	0.0163	300	94	1,148	0.032	91.1	68.6	53.0
Adjusted cycle to meet cavity and pressing constraints								
249	0.0113	420	218	1,029	0.030	84.7	48.0	55.0

3.4 Worst case red mud at reduced 45% w/w feed solids concentration

Modelling results for the worst case red mud with a reduced feed solids concentration of 45% w/w solids are presented in Table 6 to acknowledge the fact that it may not be possible to thicken a mud with poor dewaterability properties to achieve the design feed solids concentration.

The notable feature of the data in Table 6 is that the combined effects of lower permeability and lower feed solids mean that the conceptual design filter cycle results in a negative active pressing percentage, i.e. the design press duration is insufficient to even complete secondary filtration of residual slurry in the chamber, let alone achieve cake compression. To satisfy the active pressing constraint, the data in Table 6 suggests a more than doubling of the filling stage duration to around 600 seconds, or lengthening both the filling and the press stage duration. Ultimately, the adjustment of the filter cycle could be done in many ways to achieve the desired outcome. In the case of the current simulation, the resultant throughput is not overly sensitive to the strategy adopted, however, this will vary depending on the material in question. The adjusted filter cycle has a reduced filter throughput of between 43 and 46 kg/hm² (around a 35% reduction from the 68 kg/hm² for the design case).

Table 6 Worst case red mud – 45% w/w feed solids: Filter press modelling results as a function of fill stage duration. Conceptual design filter cycle profile indicated by cross-hatching. Orange shading indicates operational risk (35 mm cavity, press loading adjustment = 60 s, technical time = 300 s)

Fill/ pumping (s)	Cake deposited after fill (m)	Press (s)	Secondary filtration time (s)	Total cycle duration (s)	Final cake thickness (m)	Cavity utilisation (%)	Active pressing (%)	Throughput (kg/m ² hr)
0	0.0000	300	320	660	0.021	60.7	-6.6	61.4
228	0.0088	300	303	888	0.026	75.4	-1.0	56.7
288	0.0100	300	282	948	0.027	77.5	6	54.6
428	0.0125	300	226	1,088	0.029	81.7	24.5	50.2
595	0.0150	300	152	1,255	0.030	86.	49.3	45.7
789	0.0175	300	59	1,449	0.032	90.2	80.2	41.5
Adjusted cycle to meet cavity and pressing constraints								
428	0.0125	480	226	1,268	0.029	81.7	52.8	43.0

The adjusted filter cycle throughputs for the worst case red mud at 50 and 45% w/w solids feed are plotted against feed solids concentration in Figure 3. This data illustrates the significant compounding impact that the combined effects of lower permeability and lower achievable feed solids concentration have on filter throughput. It is common for filter design assessment to routinely consider worst case tailings as part of a filter testing plan, or at least to attempt an educated estimation of the required spare filter capacity to deal with such materials. However, a common failing in this approach is not acknowledging the risk of a lower feed solids concentration and its compounding effects. The current results indicate that this oversight could result in a significant underestimation of the required spare filter capacity, or future expansion requirements, with concurrent process and economic ramifications.

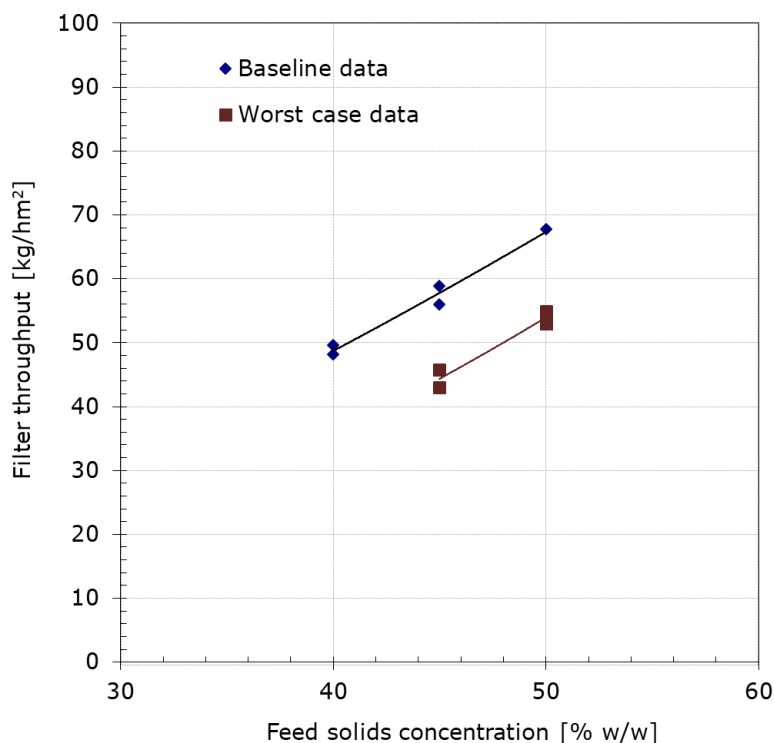


Figure 3 Comparison of filter throughput for baseline and worst case red mud as a function of filter feed solids concentration

4 Discussion

The simulation results presented in this work illustrate both the magnitude of the potential loss in filter productivity due to lower feed solids concentrations, as well as the importance of considering the compounding effect of lower feed solids and poorer dewaterability when assessing the ability of a system to cope with worst case scenarios. Whilst the need to treat plant feed that generates tailings with poor dewaterability is often unavoidable, in all cases the maintenance of the highest feed solids concentration possible will be critical to avoid processing bottlenecks or the need for installation of excess filter capacity.

It should be noted that the focus of the modelling results above was on the risks of plate damage and wet cake discharge, as well as overall filter productivity. In relation to dealing with the poorly dewatering, worst case red mud, no explicit comment was made in relation to the lower cake solids achievable for such a material (4% w/w solids lower than the base case). The lower cake solids are often seen as a process risk when taken at face value, however, in terms of meeting handleability and cake stacking criteria, attaining a fixed target cake solids is not necessarily required. This is because poorer dewatering materials will typically exhibit a higher cake strength at lower solids concentrations (hence the lower achievable cake solids for a fixed pressing pressure). Effectively, the shear strength of the filter cake, provided it is fully dewatered, is largely fixed by the pressing pressure due to the fundamental link between yielding behaviour in compression and shear (Zhou at al. 2001), and the base case filter cake at 65% w/w solids will have a comparable shear strength to that of the worst case material at 61% w/w solids. The only potential bulk handling concerns that could exist with such materials may relate to the dewatered cake being more sticky or plastic, even when fully dewatered, which could impact downstream trucking/conveying or stacking and compaction activities. Such risk should ideally be assessed via bulk materials handling testwork.

Having identified the existence of potential issues associated with lower filter productivity due to feed solids concentration or cake permeability issues, various strategies can be typically adopted, including:

- Design of surplus filter capacity, although typically value engineering practices will limit the amount of excess capacity installed. Future expansion capacity is typically something designed for in plant layouts.
- Selection of a filter design that is flexible, in particular with respect to robust filter plates that can tolerate thin cakes and diaphragm over-inflation. Utilisation of membrane plate filters as opposed to fixed cavity designs also provides more operational flexibility if regular process variability is expected (Stickland et al. 2008). However, this needs to be traded off against the higher up-front cost of membrane plates and potentially lower reliability and overall availability of membrane plates. Ultimately, the optimum solution will strongly depend on material properties and process design parameters, among other factors, and in some cases for less compressible tailings, installation of a simpler fixed cavity pressure filter, with extra capacity may be justified.
- Adaptive process control, which adjusts cycle durations in response to process conditions, is relatively common but is most effective when the filters are properly instrumented. The use of load cells to track filter weights in particular can be invaluable in tracking filter performance and implementing an adaptive control scheme to maintain optimum filter performance in the face of upstream operational variability (de Kretser et al. 2009; eds Mular & Barratt 2002).
- In some cases, short periods of off-specification feed can be accommodated by running the plant at higher availability and postponing routine maintenance, however this is not sustainable in the long-term.
- The downstream cake handling flowsheet may be designed with capability to divert off-specification cake if moisture targets are not met. This may work for slightly off-specification material, however as cake moisture levels increase, filter productivity will inevitably suffer due to wet or sticky cake discharge issues, resulting in increased maintenance and reduced availability.
- In the case of planned changes in plant feed, or processing conditions (e.g. grind size), which are known or expected to have a deleterious impact on tailings thickening and filtration, a knowledge of the risk of tailings processing bottlenecks can, and should be used to inform the production planning process, so that decisions are made from a holistic operational perspective.
- Blending (or rejecting) of problematic feed materials may be a way of reducing their process impact, although this will inevitably be contingent on other operational constraints.

Central to the ability to assess, design and implement the above process, risk-mitigating strategies is an understanding and quantification of the nature and magnitude of the risk to the process posed. This paper has illustrated how more detailed, independent dewaterability characterisation, coupled with a model-based investigation can assist in this process.

5 Conclusion

Using model-based simulations for a conceptual red mud pressure filtration facility, the significant impact of filter feed solids concentration variability on filter throughput was demonstrated. Importantly, the compound effect of a poor dewatering material, and the likely lower level to which such a material may be thickened was shown to almost double the reduction in filter productivity from the baseline design case. The results highlight the importance of adopting a holistic approach in assessing the process risk posed by filter feed variability and the value of comprehensive, detailed testing as well as model-based filter design assessment.

References

- Davies, M 2011, 'Filtered dry stacked tailings – The fundamentals', *Proceedings of the 15th International Conference on Tailings and Mine Waste: Tailings and Mine Waste 2011*, Norman B. Keevil Institute of Mining Engineering, University of British Columbia, Vancouver, <http://dx.doi.org/10.14288/1.0107683>
- de Kretser, RG, Saha, HK & Scales, PJ 2010, 'Semi-empirical full cycle optimisation of fill, squeeze and blow plate and frame pressure filters', *Chemical Engineering Science*, vol. 65, no. 9, pp. 2700–2706.
- de Kretser, RG & Scales, PJ 2011, 'Exploring the influence of feed material properties on full cycle optimisation of fill, squeeze and blow plate and frame pressure filters', *Proceedings of FILTECH 2011*, Filtech Exhibitions Germany, Meerbusch.
- de Kretser, RG, Saha, HK, Biscombe, C & Scales, PJ 2011, 'Plate and frame pressure filter optimisation using plant load cell data: Advantages, challenges and outcomes', *Proceedings of FILTECH 2009*, Filtech Exhibitions Germany, Meerbusch, pp. 300–307.
- Hore, C & Luppnow, D 2014, 'Karara iron ore TSF – Design considerations for a unique large scale dry stack facility', *Proceedings of Tailings and Mine Waste 14*, Colorado State University.
- Mular, AL, Halbe, DN & Barratt, DJ (eds) 2002, *Mineral processing plant design, practice and control: Proceedings, Volume 1*, Society for Mining, Metallurgy, and Exploration, Englewood.
- Stickland, AD, de Kretser, RG, Killcullen, AR, Scales, PJ, Hillis, P & Tillotson, MR 2008, 'Numerical modeling of flexible-membrane plate-and-frame filtration', *AIChE Journal*, vol. 54, no. 2, pp. 464–474.
- Wakeman, RJ & Tarleton, ES 1999, *Filtration: Equipment selection, modelling and process simulation*, Elsevier Advanced Technology, Oxford.
- Zhou, Z, Scales, PJ & Boger, DV 2001, 'Chemical and physical control of the rheology of concentrated metal oxide suspensions', *Chemical Engineering Science*, vol. 56, no. 9, pp. 2901–2920.