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Opportunities for Cost Reduction by By-passing Security Filtration in Alumina Production

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Abstract
Improved design of settlers/clarifiers in alumina refineries and better flocculants can reduce solids in the settler overflow sufficiently to allow part or all of the overflow to by-pass the Security Filtration area so saving operating costs and, for new plants or expansions, also saving capital costs by excluding this area from the plant design.

The economics of greenfield bauxite and alumina projects are generally not very attractive[1]. A major reason is that these projects are very capital intensive[2]. Brownfield alumina projects generally show more attractive economics, but the infrastructure requirements of several recent brownfield projects are so extensive that their economics are similar to those of greenfield projects.

From another perspective, the current economic climate, with an excess of alumina production capacity and an alumina price which has more than halved since mid 2008, provides an environment in which alumina refineries are seeking ways to lower costs, both operating cost and sustaining capex.

Several approaches may be considered to address the issue of lowering capital and operating costs. One of these approaches is to investigate opportunities to delete or by-pass complete operating steps of the Bayer process. This article describes one such opportunity in the Security Filtration area.

Security Filtration

The objective of Security Filtration in the Bayer alumina refining process is to control contamination of the alumina product by lowering the solids in the decanter/settler (sometimes first washer) overflow to the desired level in the Liquor to Precipitation (LTP).

The criteria for solids in LTP can be derived from the desired alumina quality. For instance, the AP 18/30 specification for Fe_2O_3 contamination of the alumina is <0.0165% (165ppm). Assuming 62% Fe_2O_3 present in the overflow solids and a precipitation yield of 75g/l, the maximum solids in LTP should therefore not exceed 20mg/l.

Currently the solids levels in the filtrate from Security Filtration may typically range from 5-15mg/l.

Capital & operating costs

The installed capital cost (capex) of the Security Filtration area for brownfield and greenfield alumina capacity expansion projects depends on several factors (location, refinery capacity, technology employed, etc) but may range from $15-25 per tonne of annual alumina capacity. In other words, for an alumina capacity expansion project of 1Mt/year, the capex of the Security Filtration area may be of the order of $15-25M.

The operating cost (opex) of the Security Filtration area includes fixed costs (eg labour, maintenance) and variable costs (eg filter aid, filter cloth). The total operating cost for Security Filtration differs from plant to plant, and may range from $1.2-1.8/t alumina (including sustaining capital). Lime for TCA (filter aid) normally comprises the largest element of Security Filtration's opex. To achieve the targeted settler overflow solids, alternative or additional flocculants may be required, which could result in net opex savings of the order of $0.8-1.4/t alumina in the case of fully by-passing Security Filtration.

The alumina losses related to the use of a filter aid will disappear, ranging from typically 0.4-0.7% Al_2O_3 (absolute). Thus the alumina recovery will improve by the same absolute percentage, improving bauxite consumption and lowering generation of residue. The effect of this improvement in alumina recovery on opex is not included in the numbers above.

Digestion blowoff ratio limitation
In some alumina refineries, the Security Filtration area puts a limitation on the digestion blowoff (DBO) ratio due to excessive formation of hydrated scale on the filter cloth. Settler overflow by-passing (or not passing through) Security Filtration would not put such a limitation on the DBO ratio.

The gain in DBO ratio depends on the specific situation of an existing alumina refinery, but could indicatively be of the order of 0.02-0.03 A/C ratio points. Depending on the liquor conditions of the plant and the operation of the precipitation area, this could improve precipitation yield by maybe 2-4g/l. This improvement could either be used to increase plant production capacity and/or be used to improve energy efficiency etc.

The opportunity
Decanter/settler overflow solids in current alumina refinery operations may typically range from 100-250mg/l[3]. Recently, significant strides have been made in the design of high rate thickeners and their feedwells, and similarly in the preparation of modern synthetic flocculants. This is illustrated in a paper presented by Tim Laros (FLSmidth Minerals, USA) at the Light Metals 2009 conference[4], which mentions that today's sizing parameters for settlers include an overflow clarity of 50ppm. Another illustration may be AMIRA's project P266F '*Improving Thickener Technology'* (see www.p266project.com), which includes a novel feedwell design as outlined on the website: www.p266project.com/Pages/About/ProjectAchievements.asp .

Some alumina refineries have reportedly executed tests aimed at settler overflow solids of <10mg/l, including stepwise application of a combination of flocculants achieving about 5mg/l solids, allowing part of the clarified liquor to by-pass Security Filtration. In another case, a second clarification step was performed. However no refinery seems to have implemented by-passing Security Filtration as a routine practice. Perhaps this is understandable from an operator's perspective, but less so from an operating cost perspective (as outlined above).

The current state of technology should enable solids (clarity) levels in the settler overflow to be achieved which are low enough to meet the criteria required for the solids in Liquor to Precipitation. This applies to existing refineries as well as to brownfield and greenfield projects.

Key issues are the particular nature of a bauxite residue and the scaling issues of its related liquor. Another important aspect is the protection of the precipitation area from upsets in the settler operation which could, for instance, result in too high levels of solids in the Liquor to Precipitation. This is addressed further down.

Summarizing, the recent developments in thickener design and flocculants described above provide an opportunity to lower alumina refinery operating and capital costs by (partly) by-passing or excluding the Security Filtration area. Capex and Opex savings are outlined earlier.

This opportunity may be considered in three stages: short term, medium term and long term.

Short term – existing refineries

In the short term, existing alumina refineries could consider by-passing (part of) the settler overflow past the Security Filtration area. This requires acceptable solids levels in the settler overflow and in the filtrate from Security Filtration, and could be implemented in phases as follows:

Short Term Phase 1 – no additional requirements example: If the current settler overflow solids are at 100mg/l and the solids in the filtrate from Security Filtration at 10mg/l, and if the Liquor to Precipitation (LTP) should not have more than 20mg/l solids for alumina quality reasons, about 10% of the settler overflow could be by-passed around the Security Filtration while still meeting the criterion for solids in LTP, ie without additional requirements. Operating cost savings depend on the particular plant situation and could indicatively be of the order of $0.1-0.2/t alumina.

Short term Phase 2 – Improve settler overflow solids: If in the previous example, the settler overflow solids are decreased eg to 50mg/l through a combination of using a different mix of flocculants and/or modifications to the settler feedwell, about 25% of the settler overflow could be by-passed around the Security Filtration while still meeting the criterion for solids in LTP. Depending on the mix of flocculants required opex savings could be of the order of $0.2-0.4/t alumina.
This step would require some laboratory test work to investigate which different mix of flocculants would result in the required settler overflow clarity improvement. Modifications to the feedwell may also be required.

Short term Phase 3 – Full by-pass of Security Filtration: The results from Phase 2 could provide the basis to further improve the settler overflow solids to the point that no settler overflow passes through Security Filtration. Depending on the requirement of a different mix of flocculants and the current usage, opex savings could be of the order of $0.8-1.4/t alumina.
Once all of the settler overflow by-passes the Security Filtration building, the digestion blowoff (DBO) A/C ratio may be increased at those refineries where the Security Filtration area puts a limitation on the DBO ratio due to the excessive formation of hydrate scale on the filter cloth. The gain in DBO ratio depends on the specific situation of an existing alumina refinery, but could indicatively improve precipitation yield by 2-4g/l.

Strategy for high solids in settler overflow

This short term opportunity requires developing a strategy on how to handle an upset in the operation of the settler(s) that could result eg in too high solids levels in Liquor to Precipitation (LTP). The upside of this important aspect is that the operating measures required to redress this situation are similar to the operating steps currently in place if such an event was to happen today. In addition or perhaps alternatively, the settler overflow at an undesirably high solids level for LTP may be directed to an offline settler overflow tank until the required number of security filters have been put online. Details of required steps may differ for an individual refinery.

It should be kept in mind that for this short term opportunity the fallback position is to re-direct the settler overflow to the existing Security Filtration area, ie reverting to the situation before the settler overflow by-passed this.

Medium Term – Brownfield expansion projects
The medium term perspective is to consider the opportunity as an element of a brownfield production expansion project for an existing refinery. Refinery capacity expansion projects of typically 500kt/y alumina and above are generally considered brownfield expansions as they often require additional trains/units to be added to some of the major plant facilities (eg digestion, precipitation).

In this medium term case the opportunities are in excluding new (additional) Security Filtration capacity from the scope of the brownfield project.
The design of modern mud settling facilities as offered by several technology suppliers enables settler overflow solids to be achieved which are acceptable for direct feed to the precipitation building. Designs by these companies may include proprietary feedwell designs and/or feedwell modifications developed in co-operation with others.
A key issue is the specific nature of the bauxite residue and therefore laboratory residue settling test work is required to investigate which flocculants or combinations of these will result in the required settler overflow clarity. Co-operation with a flocculant provider for the design of the mud settling equipment should be effective and is recommended.

The potential cost savings include the following:

- *Capital cost (Capex) savings:* The actual brownfield capex for Security Filtration depends on the scope and context of the project and consequently may vary widely. However when a new or expanded existing Security Filtration building is required, the capex may range from \$15-25/t annual alumina capacity. For a brownfield expansion project of 500kt/y this would mean a capex of about \$8-13M.

  Although (slightly) modified clarification equipment may be required (eg modified feedwells), and/or some alternative equipment may be considered for inclusion in the scope of the brownfield project (e.g. an extra settler or an additional settler overflow tank), the related additional capex~~,~~ is expected to be of a second order of magnitude, ie expected capex savings are as indicated above.

- *Operating cost (Opex) savings:* The total opex for Security Filtration may range from \$1.2-1.8/t alumina. To achieve the targeted settler overflow solids, flocculant costs may increase, therefore net opex savings would be of the order of \$0.8-1.4/t alumina.

The medium term opportunity requires, similar to the short term opportunity, developing a strategy how to handle an upset in the operation of the bauxite residue settler(s). This would be part of the design of the brownfield project and could, for instance, include a second (spare) settler and/or additional settler overflow tanks. For some brownfield expansion projects the existing Security Filtration building may provide (some) excess capacity that may be put to use in case of upsets of the settler operation.

It is expected that the overall annual plant operating factor of a state-of-the-art design brownfield alumina project which excludes a Security Filtration area should not be significantly different from a similar design which includes Security Filtration. Plant design should include state-of-the-art process controls in the digestion and clarification areas.

Long Term – Greenfield expansion projects
The long term perspective is to consider the opportunity as an element of a greenfield alumina project and is similar to that of the Medium term case: excluding a Security Filtration area from the scope of a greenfield project.
Laboratory test work is essential to investigate which combination of flocculants will result in the required settler overflow clarity.
Cost savings are similar to those for the Medium term case as follows:

- Capital Cost Savings $20-25/t annual alumina capacity. The low end of this range is higher than that of the Medium term case, because the option of expanding an existing Security Filtration building does not apply to a greenfield project.
- Operating Cost Savings $0.8-1.4/t alumina.

Implementation opportunities
In the current economic climate, alumina producers with operating alumina refineries (eg Alcoa, BHPBilliton, Dadco-AOS Stade, Nalco-Damanjodi, Rio Tinto Alcan, UC Rusal, Vale-Alunorte etc) are actively looking for ways to quickly lower operating cost and sustaining capital.

Short term in existing refineries
The short term opportunity fits that context very well. An additional advantage is that this opportunity allows phased implementation as described. The expected implementation period for phases 1-3 is four to seven months.
Co-operation with a flocculant provider (such as Ciba, Cytec, Nalco, SNF Floerger, etc) would not be an absolute requirement for this step, however, it would assist in speeding up its implementation. If modifications to the feedwell of the settler(s) are contemplated, co-operation with AMIRA/CSIRO or a technology supplier (such as FLSmidth Dorr-Oliver Eimco, Hatch, Outotec etc) may be appropriate.

Medium term brownfield expansions
The medium term opportunity is attractive to alumina producers that are considering a brownfield capacity expansion as well as to technology suppliers offering technology for brownfield expansion projects to the alumina industry. The implementation period, if large scale tests in the existing refinery are included, is expected to require four to nine months in addition to the time normally required when the brownfield project design includes Security Filtration.

Long term greenfield expansion

The attractiveness of the long term opportunity is similar to that of the medium term one, i.e. both to alumina producers as well as to technology suppliers. The implementation period is expected to require one to three months in addition to the time normally required when the greenfield project design includes Security Filtration.

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