APPLICATION OF PLATE AND FRAME PRESSURE FILTERS TO RED MUD RESIDUE

D. J. Cooling[1]*, L. Myers[1], L. Bosworth[2]

[1] *Alcoa, Cockburn Road, Kwinana, WA, Australia*

[2] *Major Projects, Alcoa of Australia, WA*

Corresponding author: david.cooling@alcoa.com.au

ABSTRACT

The extraction of alumina from bauxite produces a residue which is typically stored in secure impoundments adjacent to the alumina refinery. At Alcoa's Western Australian refineries, the fine fraction of this residue is thickened and deposited across large drying areas, where solar evaporation reduces the water content and increases the strength of the deposited residue. Alcoa has been assessing the viability of plate and frame pressure filtration of red mud residue to enable mechanical stacking of the residue as an alternative to this current method of deposition and evaporative drying of the thickened slurry. This paper outlines some of the development work and an overall assessment of this alternative technology undertaken by Alcoa.

1. INTRODUCTION

Alcoa of Australia Limited (Alcoa) has three refineries in Western Australia, at Kwinana, Pinjarra and Wagerup, with a combined capacity of approximately 9 million tonnes of alumina per annum. During the refining process, a caustic soda solution is added to the bauxite to dissolve the alumina, allowing separation of the alumina (in solution) from the un-reactive solids. Although the solids are washed to recover and recycle caustic, the final residue still contains a residual level of caustic, or alkalinity, and the solution entrained with it has a pH of approximately 13.5.

Bauxite residue from Alcoa's Western Australian refineries is characterised by a coarse fraction, which is separated from the fine tailings using cyclones and counter current wash towers. The fine tailings are pumped to a thickener vessel where they are flocculated and settled, producing a thickened slurry of approximately 45% w/w solids. This slurry is pumped to one of a number of drying beds where it is placed in layers of up to 1m depth and allowed to consolidate and dry via solar evaporation. The final dry density of the deposited residue is around 65-70% w/w solids. The coarse sand fraction of the residue is used for the construction of drainage layers and upstream perimeter embankments to the storage area which is constructed as a progressive stack.

To sustain this method of "dry stacking", a large active surface area is required. The available area for stacking is reduced as the stack height increases, necessitating the construction of new drying beds to maintain the required minimum drying area. This places a large sustaining capital commitment on the refineries. Alcoa has been investigating alternative storage methodologies, with a view to reducing this ongoing capital requirement which has lead to a detailed study into the potential use of residue filtration. The concept for such a process is outlined in broad terms below.

- Coarse and fine residue separation as per the current system
- Thickening of the fine fraction, again as per the current system
- Filtration of the fine fraction to a low moisture content cake (moisture below the point at which the cake will re-slurry)
- Conveying of the cake to a localised stacking area
- Mechanical stacking of the cake from a mobile "spreader"
- Machinery utilised to aid the stacking and to compact the cake to a minimum volume

Residue filtration offers a range of additional benefits over the current practice of dry stacking. These include improved fluid

recovery to the refinery and a smaller active residue storage area.

Critical to this technology is the assessment and selection of filtration equipment that can produce a residue cake at moisture contents suitable for handling. The following discussion outlines testing completed to date to aid in this equipment selection along with a range of other technical considerations.

2. TARGET MOISTURE CONTENT

Saturated soils are at risk of cyclic softening when exposed to vibrations. As the filtered residue material is likely to be transported to the deposition area via a conveying system, the material may be exposed to vibration. This may lead to softening of the filtered residue in transport which could in turn result in operational difficulties.

A series of tests were undertaken as a part of a preliminary scoping study for a potential filtration system to examine the filtered residues propensity to liquefy. Because this is a function of both the amplitude and the frequency of the loading, cyclic load testing was performed using multiple methods to cover a wide spectrum of possible loading. The testing indicated that liquefaction would be unlikely to occur on a conveyor belt for filtered residue material below a saturated water content of 32%.

Based on this work, an initial target moisture content of less than 31% was established for the filtration plant design.

3. FILTRATION TESTING

Figure 1 shows the relationship between the maximum compression and moisture content for Alcoa residue mud based on compressibility testing data and field assessments of consolidation characteristics (Cooling, 1985) together with the working zones of various technologies. Based on this, plate and frame (P&F) pressure filters were selected as the most applicable technology for the application.

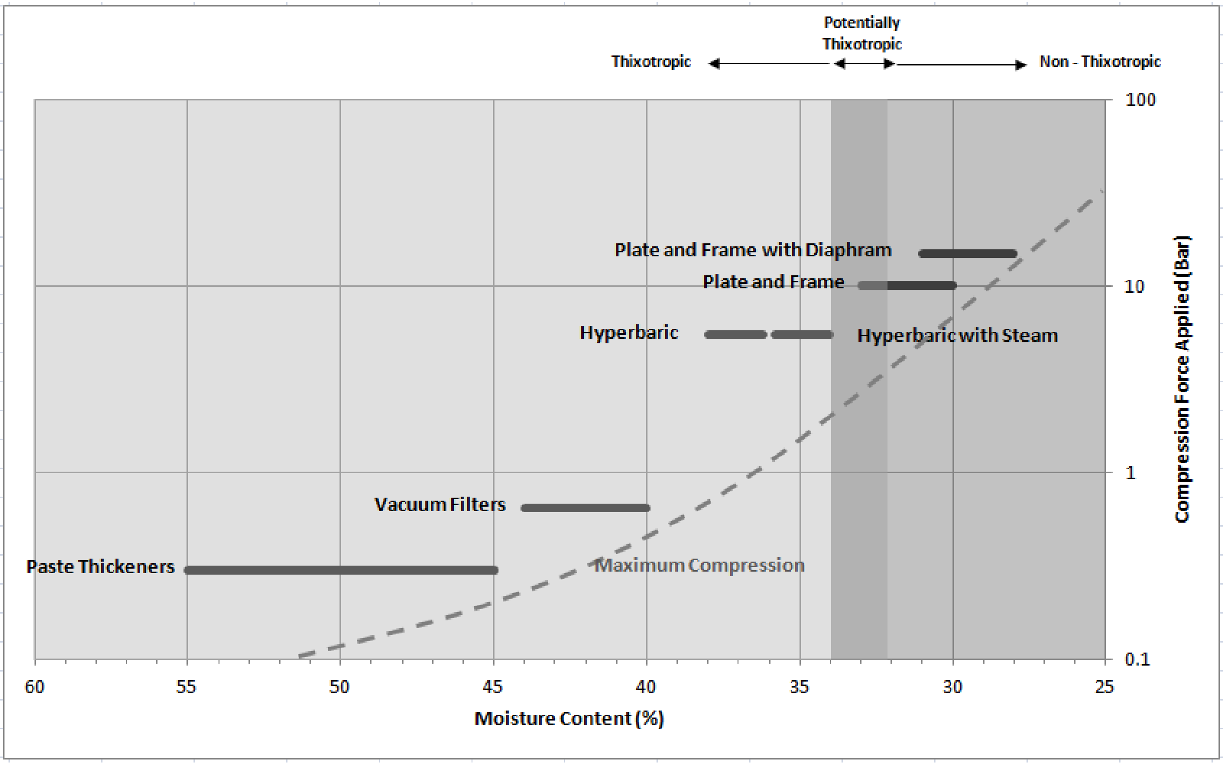

Figure 1. Range of test results from various thickening and filtration equipment

Over recent years, the use of P&F pressure filters has become more common in the minerals industry, and in particular for the treatment of tailings. This is now being extended into the alumina industry, with a number of examples where this type of equipment is being applied to red mud slurries. These can operate at filtration pressures typically between 6 to 12 Bar, however this can be increased further to around 15 Bar through the use of a pressurised diaphragm in the slurry chamber.

Alcoa has recently conducted both bench and pilot scale testing on P&F filters. Typical results are shown on Figure 2. These results were produced from a small pilot plant with slurry chambers of 500mm x 500mm in size. Various recessed chamber depths were tested, with and without diaphragm squeezing. This test work demonstrated that moisture contents in the range of 30% to 32% were readily achievable without the need for diaphragm squeezing.

Based on this testing, a simple chamber press (without diaphragm squeezing), operating at a pressure of up to 14 Bar was able to achieve the desired moisture content of the cake at relatively conservative filtration rate of 65kg/m2.hr.

4. FILTER ASSESSMENT CRITERIA

Plate and frame filters generally fall into two broad categories; those where the plates are supported from an overhead beam and those which are supported from side beams. The function of both types is similar (slurry dewatering within a recessed chamber between the plates). However filters may have a number of associated features and ancillary functions which may be specific to the filter type or supplier. The specific features of each potential filter must be assessed to determine it suitability for the application.

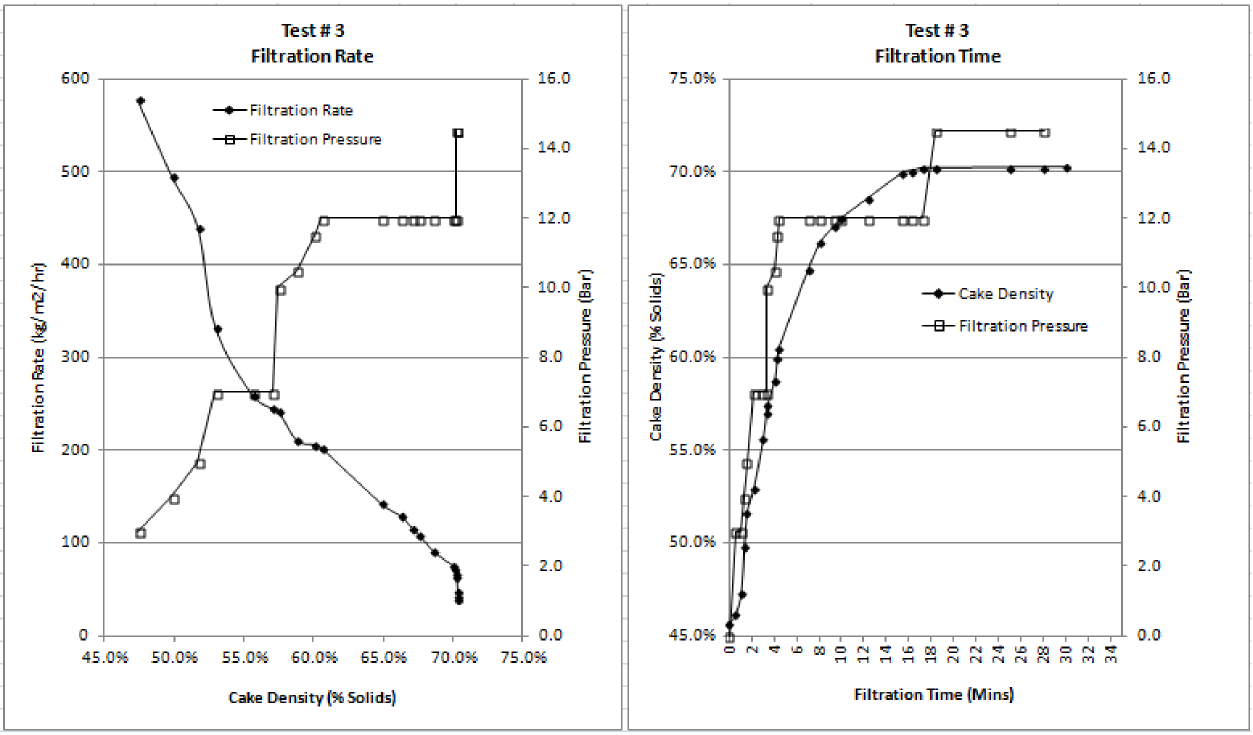

Figure 2. Typical test results from a pilot P&F filtration plant (chamber thickness 32mm)

The main filter features that may vary include;

- Cake formation; simple recessed chamber or assisted by membrane compression within the chamber
- Closing system; the number of hydraulic rams spreading the closure load either in compression or tension Filter cloth type; needle felt or woven fabric
- Cloth washing; multiple high pressure sprays covering multiple plates simultaneously or individual plate wash sequentially
- Assisted cake removal; on either multiple or individual cloths/plates, by vibration, shaking or flicking of the cloth
- Cloth change-out; in-situ cloth change, overhead "hanging cloth" cloth change, or overhead cloth with plate change
- Plate change-out; side plate removal or overhead plate removal.

Alcoa has reviewed the equipment available in the market and established the following criteria to assist in determining a suitable technology.

4.1 Cake formation

Testing clearly demonstrated that the target cake moisture can be readily achieved using a simple recessed chamber press if a slurry feed pressure of between 12-14 Bar is applied. Membrane squeezing of the cake is not required to achieve this moisture content. Therefore a simple chamber press is sufficient for the application.

4.2 Closing system

Each filter press design reviewed used hydraulic rams to close the press and with sufficient external force (in the order of 400 Bar) to seal the plates. Generally the side frame presses used push rams, whereas the overhead frame presses used pull rams. An important consideration is the number of rams; once the plate size exceeds 1-1.5m, four rams are required (one in each corner of the head frame) to spread the load and prevent damage to the frame and plates. The Alcoa application will probably require a plate size in excess of 1.5m, so a four ram closing system considered an essential design requirement.

4.3 Filter cloth type

There are two main types of cloth; needle felt and woven fabric which can be used interchangeably on the filter presses reviewed. Woven fabric may be more expensive and may provide a lower clarity for the returning filtrate; however it provides superior cake release properties and increased wear resistance to high pressure cleaning. As a result, it is the preferred cloth type for the application.

4.4 Cloth washing

Cloth washing serves to both remove cake from the cloth surface and also to provide some regeneration of the cloth filtration performance.

In some filter press applications, like mineral concentrate filtration, the cloth wear rate is sufficiently high that high pressure cloth washing is not required to regenerate filter cloth performance. However for this application, the cloth life is expected to be around 3,000 to 5,000 cycles so high pressure regeneration of the filter cloth was considered important. A system that included an efficient high pressure cloth cleaning and regeneration was therefore required to reduce the cloth change out rate and improve operating costs and press availability.

There are two approaches to cloth washing that include high pressure cloth cleaning. The first approach uses a combination of high and low pressure fixed spray nozzles that are used each cycle to wash the cloths. Typically a set of low pressure spray nozzles is fitted across the top of each chamber to provide an "inundation" or flood wash, where the wash water flows at low velocity down the face of the cloth. A second set of high pressure spray nozzles, located around the sides of the cloth, provide a higher velocity spray in various directions across the cloth face. This system is designed to remove any solid cake material left on the surface of the cloth and the sealing faces, but is not designed to clean between the cloth fibres because the spray is directed across the face of the cloth and not perpendicular to it. In such a system the high pressure wash spray is not contained and so will generate a mist of fine droplets that will drift outside the press boundary into the surrounding building.

In an alumina refinery application, existing low alkalinity circuit water provides a convenient water source for this type of washing. Any overspray mist will therefore contain some caustic and may therefore require additional countermeasures to ensure safety and hygiene standards are met in the filtration

area. For example overspray containment could be managed by installing a housing around the entire filter, however this type of mechanical countermeasure would present an additional layer of cost and complexity to filter installation and operation.

The other approach to cloth washing is an individual plate wash system, where the filtration cycle is interrupted periodically (typically once or twice per day), and each cloth is individually washed by a high pressure head that indexes down the plate pack, washing each plate in turn. This system can reduce the overall productivity of the press as time needs to be allowed for the wash cycle (typically 60-90 mins), although in practice the total press washing time per day is similar between the two systems.

There appear to be two main advantages of the individual indexing high pressure wash system. Firstly the high pressure sprays are housed between two sets of brushes; this limits the breakout of any overspray from the press. Secondly, as the high pressure nozzles are sited perpendicular to the filter cloth the high pressure spray is directed into the cloth weave and will assist to remove any build up of solids within the cloth and provide some regeneration of the cloth filtration performance.

4.5 Cloth Shaking

The requirement for cloth shaking is generally dictated by the type of filter and the material being filtered. Typically the cloths on the side beam filters are shaken at the end of each cycle via a cam system that repeatedly lifts and drops the cloth through a short distance. With the overhead beam filter, the cloths can be shaken individually as the plates open. There are several methods for achieving this; typically they work by 'flicking' the cloth as the plate swings open.

The cloth shaking system employed by the side beam filters is likely to be more effective; however information obtained from installations operating on red mud suggests that cake hang-up in red mud filtration application is not likely to be an issue, and either method should be suitable.

4.6 Cloth change-out

Cloth change outs are handled differently depending upon the type of filter press used. Some side beam presses use a system of 'hanging cloths'. With this system, the cloths are supported separately from the plates and can be removed by lifting them from the top of the press either individually or in groups. Other side beam presses have the cloths fixed to the plates; to change a cloth the plate and cloth assembly has to be lifted through the top of the press and taken to a separate maintenance area for the cloth to be removed and replaced. Again the plate and cloth assemblies may be removed individually or in groups.

The top beam design presses open with a gap between the plates; this provides sufficient space to allow access between the plates to change the cloths in-situ. Each reclothing method has inherent health and safety challenges that need to be managed. Side beam presses require operator access, usually via a mezzanine floor around the top of the filter which is fitted with fall protection. Nonetheless operation may require additional fall risk protection such as the use of safety harnesses while working on the mezzanine floor which introduces additional complexity to both design and operation.

If the cloths are to be removed by removing the entire plate and cloth assembly from the filter, a separate cloth change area and associated apparatus and tooling is needed. This area will need to be set up such that there is safe access to the sides, top and bottom of the plates. Each filter plate is likely to weigh around 400kg each so manipulating and manual handling the plates during the remote reclothing process will introduce a range of additional safety and ergonomic issues.

In-situ cloth change will require entry into the press plate pack area. While this resolves the fall risk associated with accessing the top of the press, and the multiple handling issues associated with removing the plates from the press, a failsafe lock-out tag-out isolation procedure will be required to ensure entry into the press can be managed safely.

The project team established that the in situ cloth change out procedure represented the lowest risk and was therefore the preferred option. Re-clothing will be the main maintenance activity on the press and therefore it will be critical that the process can be managed safely, easily and efficiently.

4.7 Plate change-out

The method of plate change-out is dictated by the type of filter. With a side beam filter, the plates must be removed from the top of the

press. This is done with the overhead crane and is a relatively simple process; often multiple plates can be removed at one time. Plate removal does introduce the falls risk described in the cloth change out section above.

With an overhead beam filter, the plates must be removed from the side of the press. The plates must be removed individually, and this is generally done with the aid of a lifting cradle. The cradle may be supported from the overhead crane, or by a small mobile lifting frame wheeled in from the side of the press. Plate changes should not be a frequent activity, (the expected life of a filter plates is 10 years), and so either method should be acceptable.

5. CONCLUSIONS

Alcoa has been investigating alternative technologies for the ongoing storage of bauxite residue with the objective of avoiding the ongoing capital required to sustain large active drying beds. Residue filtration could achieve this objective by reducing or removing the requirement for residue drying and therefore reducing the surface area required to store residue. The technology offers a range of additional benefits, including improved water recovery.

Based on the overall assessment of technologies available, plate and frame pressure filters were selected as the preferred equipment. The overall function of plate and frame filters is similar; however filters may have a number of associated features and ancillary functions which may be specific to the filter type or supplier. The specific features of potential filters were assessed to determine the preferred features suitability for the red mud filtration application.

1. A simple recessed chamber press is preferred. Testing has shown that membranes are not required to achieve the final cake moisture and no cake washing is required, so the additional expense and maintenance costs associated with membranes can be avoided.
2. Given the size of the filter plates and the forces involved in holding the plates in a closed position, four hydraulic closing rams are required to spread the load and prevent bending of the frame.
3. Individual high pressure cloth wash system at right angles to the filter plate is preferred to the inundation or flood wash systems. Filter cloth regeneration is an important requirement during the life of the cloth and with the preference for in-situ cleaning to avoid excessive cloth change-out.
4. Safe cloth change out methodology with specially designed access is required. In-situ cloth change is considered to be safer than accessing the press from the top due to potential fall hazard issues with the top access systems, and also less manual and multiple handling of heavy filter plates outside the press. However, either method will require specifically designed access to ensure safe work practices.

6. REFERENCES

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