

Implementation and Optimization of Filter Press in Red Mud Washing Process at Eti Aluminium

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Abstract

Red mud management is a major and ongoing issue for review within alumina refinery operations. The accumulation of large tonnages of red mud, accompanied by significant volumes of supernatant liquor which cannot be returned to the process, requires a very large disposal area. Importantly, the volume of liquor present significantly reduces the life time of the containment dam in the residue disposal area. For this reason, the red mud issue is particularly significant also because of the environmental themes linked with the dewatered material storage. To both prevent unwanted environmental results in the future and handle this process residue responsibly, an extensive research programme should be executed to find the most efficient way of minimizing any problems by using state of the art technology. ETI Aluminium has the capacity to process 550 000 tonnes of bauxite, produce 250 000 tonnes of alumina per year which generates approximately 260 000 tonnes of red mud. Red mud slurry was formerly disposed as 30 % (w/w) solids and less than 5 g/L Na₂O to red mud dam. A number of alternative dewatering technology trials were carried out by ETI Aluminium; the best performance was achieved with a horizontal press filter due to its high efficiency residue handling optimization in red mud filtration. Following these trials, ETI Aluminium invested in an automatic horizontal press filter in the red mud washing cycle. This paper describes the performance, operation and parameters of the new red mud handling process with press filter in ETI Aluminium.

Keywords: Bayer process, red mud, bauxite residue, filter press, dewatering, process optimization.

1. Introduction

Red mud management is a major and ongoing issue for review within alumina refinery operations. The accumulation of large tonnages of red mud, accompanied by significant volumes of supernatant liquor which cannot be returned to the process, requires a very large disposal area. Furthermore, the volume of liquor significantly reduces the life time of the containment dam in the residue disposal area. Therefore, the red mud causes many problems taking into account environmental concerns linked with the wet material storage. An extensive research programme should be executed to find the most efficient way to prevent unwanted environmental impacts in the future and handle this residue, using state of the art technology.

Currently, the solid content from ETI's conventional last washer thickener is about 30 % (w/w) prior to pumping to the dam. Some alternative dewatering technology trials such as deep cone thickener, vacuum filtration, decanter centrifuge and filter press were carried out by ETI. From latest technological paste thickening application point of view, 33 to 40 % solids in the underflow seems to be achievable with the existing ETI Aluminium red mud characteristic. Also using vacuum filtration and centrifugal decanter technology, the achievable cake solids content

is around 47 % and 55 % respectively. The best performance was achieved with a horizontal press filter due to its high efficiency in terms of dryness, liquor recovery rate and capacity. ETI has been expecting a high-solid content cake from the filter press that will consume less volumetric flow-rate and let more residue to dispose in a given waste mud dam as well as higher caustic recovery from the washing circuit [1].

In this paper, the physical, chemical and mineralogical characteristics of ETI red mud have been reviewed. Further, this paper describes ETI's operational experience based on performance parameters of the new red mud handling process with press filter.

2. Physical and Chemical Analyses of Red Mud

ETI red mud is a residue from the common Bayer method, processing boehmitic bauxite. Semi quantitative elemental analysis of red mud has been obtained via ARL Advant'x 2098 Quantas and is given in Table 1 [2].

Table 1. Element Analysis of red mud (wt. %).

Element	wt. %	Component	wt. %
Al	9.87	Al ₂ O ₃	18.65
Ca	2.71	CaO	3.80
Fe	25.22	Fe ₂ O ₃	36.03
K	0.34	K ₂ O	0.41
Mg	0.17	MgO	0.28
Na	6.62	Na ₂ O	8.92
S	0.04	SO ₃	0.10
Si	7.58	SiO ₂	16.24
Ti	3.03	TiO ₂	5.05

Red mud XRD analyses have been performed using a Siemens XRD diffractometer. The values obtained are shown in Table 2. The main phases found are hematite and silica containing minerals. XRD analyses have been supported by XRF analysis. [2].

Table 2. Mineral phases in red mud.

Mineral Phases in Red Mud	wt. %
Hematite, Fe ₂ O ₃	35.54
Sodalite, Na ₄ Al ₃ Si ₃ O ₁₂ Cl	6.08
Cancrinite, 3NaAlSiO ₄ .NaOH	6.45
Sodium Aluminosilicate hydrate, Na ₆ (AlSiO ₄) ₆ .4H ₂ O	26.54
Calcite, CaCO ₃	1.34
Gibbsite, Al(OH) ₃	1.09
Boehmite, AlO(OH)	0.62
Diaspore, AlO(OH)	4.64
Goethite, FeO(OH)	0.54
Sodium Titanate, Na ₂ Ti ₆ O ₁₃	1.06
Rutile, TiO ₂	2.55
Tridymite, SiO ₂	2.34

The particle size distribution of red mud has been analyzed using a Malvern Mastersizer and is shown in Figure 1. It has been found that the d_{50} is 2.86 μm and d_{90} of red mud is finer than 12.8 μm . Water was used as a dispersant agent during analyses. The pH values of bauxite residues slurry are in the range 10 – 13. The conductivity values of slurry are in the range 40 – 60 mS/cm.

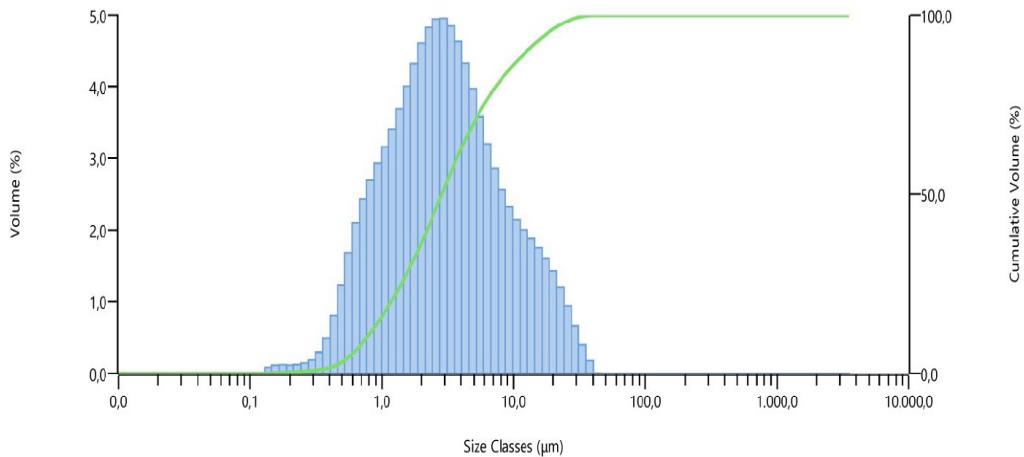


Figure 1. Red mud particle size distribution.

Specific surface area of red mud has been defined as 28.4 m^2/g with N_2 BET method using a Quantachrome Nova 2000e unit. The specific gravity of red mud solids has been measured as 2.95 g/cm^3 using a Quantachrome Ultracycrometer.

3. The Operational Experience on Red Mud Handling Process with Press Filter

The following values are the targets for press filter operation:

- Filtration capacity: 47 500 kg (DS)/h max.(without cake washing), (99 $\text{kg}/\text{m}^2/\text{h}$)
- Moisture in cake: ≤ 30 wt. %
- Filtrate clarity: ≤ 500 mg/L

The operation of the filter is controlled automatically by a PLC controller. Filter press opening and closing is carried out in two stages. The plate pack is opened for cake discharge and closed again for next filtration cycle with long stroke quick action cylinders. Filter is equipped with cloth shaking and cloth flushing systems for improved cake discharge and reliability. Cloth flushing is applied after each cycle when the plate pack is open and cake discharge is complete. Flushing water is collected with swivel plates underneath the plate pack [3].

Slurry is fed into filter chambers through a top feed channel. The slurry inlet, filtrate collecting, drying air supply and pressing air supply are integrated into the polypropylene filter plate. The slurry channel is cleaned and emptied with a core flushing and blowing steps after each filtration cycle, before cake discharge. The filtration process steps are sequenced as below [3].

- Filling
- Filtration
- Pressing
- Cake washing
- Air drying

- Core flushing
- Core blowing
- Membrane release
- Cake discharge
- Cloth flushing

The filter can be operated fully automatically and run in any mode (such as cake washing, without cake washing, drying, without drying, etc.).

The last washer underflow slurry is first sent to the filter feed tank. The mother and wash filtrates are collected in a tank to feed back to the washer train. The filter cake drops down followed and is excavated and transferred to the red mud dam, which is about 4 km away using trucks. The new process flowsheet is given in Figure 2.

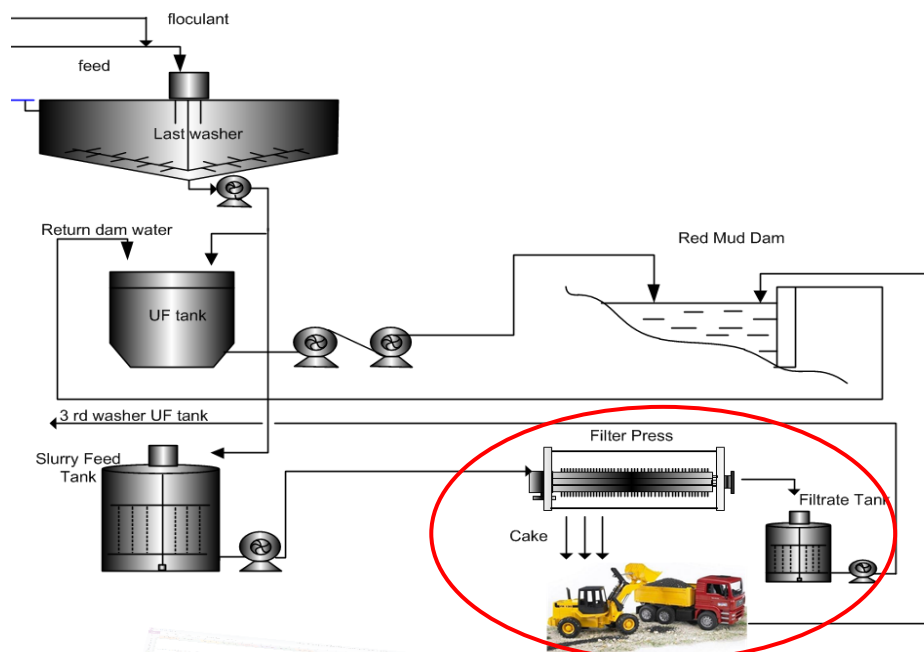


Figure 2. Current washing and filter press system

The filter press is designed to operate at the process conditions described below:

- | | |
|------------------------------------|--------------------------|
| • Slurry density | > 1250 kg/m ³ |
| • Liquid density | 1000 kg/m ³ |
| • Specific gravity of solids | 2.95 kg/dm ³ |
| • Dry solids content (feed slurry) | > 30 wt. % |
| • Slurry pH | 12 – 14 |
| • Temperature of slurry | 90 – 95 °C |
| • Slurry feed pressure minimum | 600 kPa |
| • Pressing pressure max | 1200 kPa |
| • Cake washing liquid temperature | 90 – 95 °C |

The cake moisture, leachable soda content of cake, filtrate quality and cake drying & washing performance have been followed. In addition, one of the most important parameter in the pressure filtration processes is the selection of the suitable filter cloths. Four types of cloth have been chosen for trials.

The cake moisture has been significantly decreased after filter press start-up as is shown in Figure 3. The average moisture content is about 30 % after filter press application.

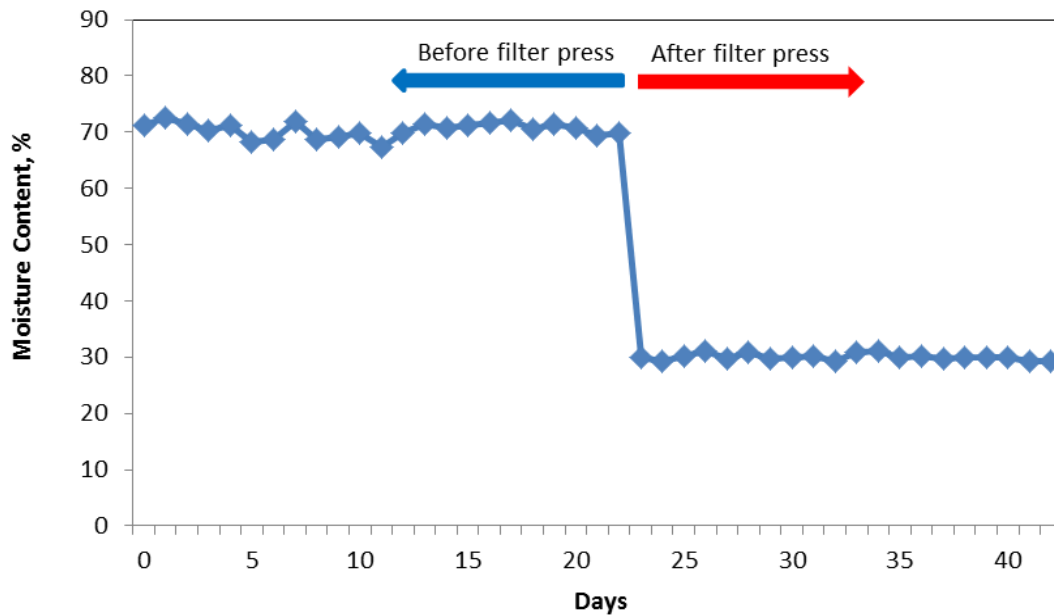


Figure 3. Cake moisture trend.

There is an obvious difference with and without cake wash in the leachable soda content of filter cake as shown in Figure 4. The filter press is able to give better values with a reasonable wash water ratio.

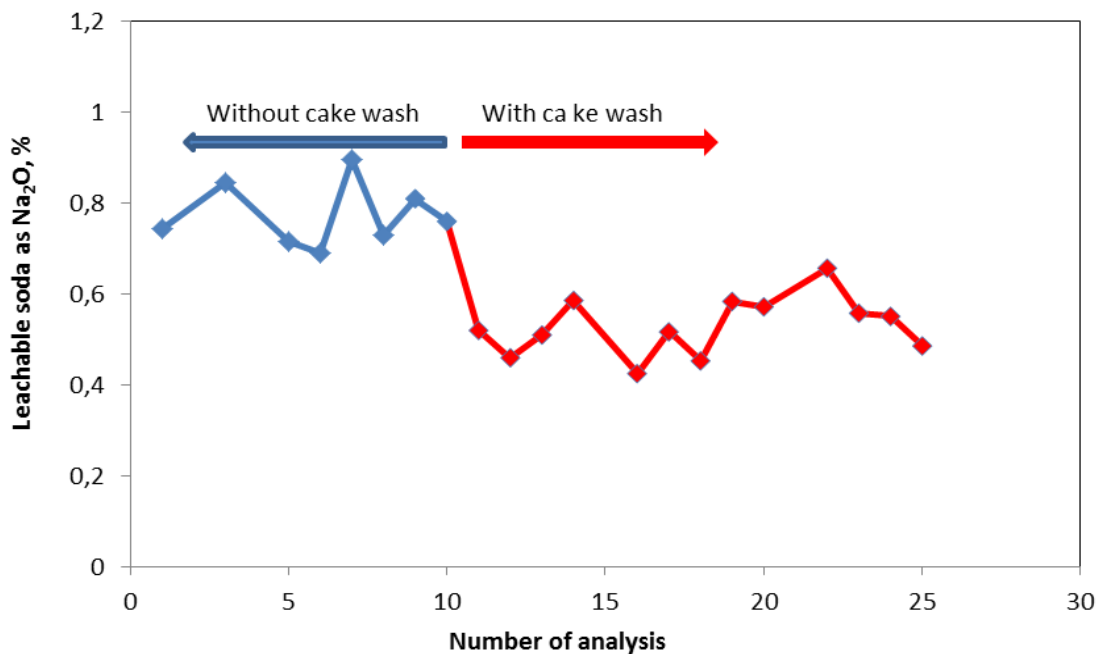


Figure 4. Leachable soda contents with and without cake wash.

The filtrate quality is really lower than expected as is shown in Figure 5. So far, the filter cloths used seems to be robust and efficient.

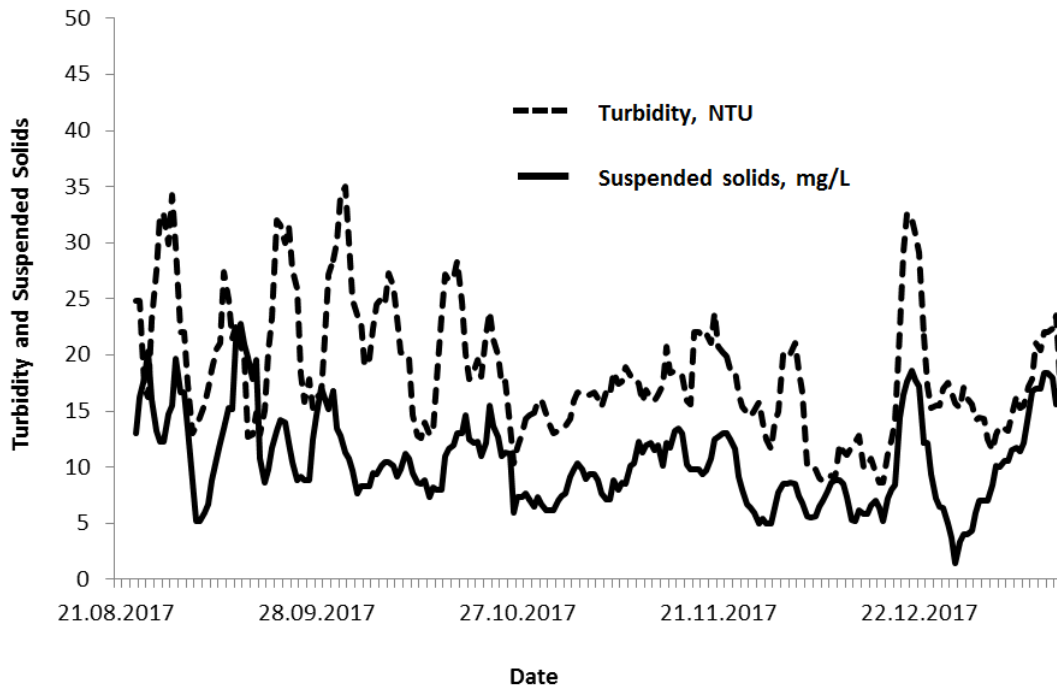


Figure 5. Filtrate turbidity and suspended solids analyses.

According to NTU and suspended solids values in the filtrate, turbidity values average 30 NTU and suspended solids average 12 mg/L.

The filter cloths have been on trial. The best performance achieved is over 3000 cycles regarding the life time. The aim is to improve this value to at least 5000 cycles.

4. Conclusions

Red mud filterability is a challenge due to its nature and the fine particle size distribution. However, ETI's red mud was successfully filtered through filter presses. The overall performance values have presently met the expectation.

The evaluation of the actual reliability of the filters and the sustainability of the operation requires a greater amount of time in operation. In the meantime, it is possible to capture accurate OPEX and maintenance costs to assist this evaluation.

This filter press technology will bring many environmental and process advantages such as:

- Reducing the disposal area required for red mud storage;
- Minimizing the potential for liquor release to the surrounding environment;
- Maximizing the recovery of the caustic rich liquor to the plant;
- Reducing the consumption of natural source water during the red mud washing process.

The caustic soda recovery seems satisfactory, however reducing the blow down of supernatant liquor and keeping it in process can be another challenge as mismanagement can cause a buildup of impurities in the Bayer liquor, and therefore must be closely monitored.

On the other hand drier red mud can create a potential opportunity to further usage of red mud in refractory, cement and construction industries. Moisture content and lower soda values are very important parameters considering the transportation of bauxite residue and its usage as a raw material.

5. Acknowledgment

This technology has been implemented and will be monitored with cooperation between ETI and Outotec.

6. References

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