

Bauxite Residue Dewatering by Pressure Filtration: a Versatile and Customizable Solution for Dry Stack Disposal

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Abstract

Tailing dry stacking can nowadays be considered a proven technology for bauxite residue disposal. An increasing number of aluminum refineries are converting the traditional tailings ponds into filter press cake dry stacking. This trend is favored by a series of advantages, such as reduced risk of external dam wall failure and, consequently, red mud spill, lower environmental footprint and higher soda recovery. The red mud proceeding from the Bayer process is the underflow of the last thickener of CCD system. The physicochemical characteristics of this red mud and, consequently, their dewaterability properties, can be significantly affected by several parameters and, in particular, by the bauxite ore composition. For this reason, pressure filtration is the suitable technology to get high and consistent performances, due to its versatility. In view of the long-term experience in mining tailings filtration, Diemme[®] Filtration, part of the Aqseptence Group, designed filter presses specifically to treat different red mud types in order to provide an effective dewatering system for a wide range of bauxite ores. In this work we are presenting a series of real case studies, involving Diemme[®] Filtration filter presses installations, demonstrating how the physicochemical characteristics of the residue affects its filterability and how the filtration system can be consequently optimized in order to achieve the target required by the customer.

Keywords: Filter press, dry stacking, red mud disposal, characterization, cake filtration.

1. Introduction and Aim of the Work

The disposal of red mud is still one of the main challenges of bauxite refining industry. [1] It is estimated that, every year, >150 tonnes of residual bauxite are produced, considering that a ton of alumina generates 1.5 tonnes of waste. Red mud is usually produced by a CCD plant, where the bauxite residue is washed in order to improve the recovery of soda, reducing the alkalinity of the material. The characteristics of the resulting residue slurry, which is extracted as underflow from the last thickener of the CCD, highly depend on the type of bauxite ore and on the process conditions. Many efforts are directed to the improvement of the waste disposal methods, [1, 3-4] with a series of well-defined aims:

- Reduction of the dangerous environmental impact of red mud;
- Recovery of soda, with consequent economic advantages;
- Reevaluation of the residue through the employment of alternative methods to disposal.

There are different methods traditionally used for the treatment of red mud, for instance neutralization with discharge into the sea, lagooning and filtration.

Filtration is surely the system that permits achievement of the aforementioned goals more than any other method. [2] Among all the current available technologies, the most promising one is the filter press due to the high achievable performances. Filter press filtration provides the ability to obtain very high dewatering levels, producing dewatered slurry cakes with residual

moisture values as low as 30-20% w/w, which are compact and perfectly transportable and stackable. Compared to the traditional filtration technologies (i.e. vacuum drum filters or hyperbaric filters), this represents an important step forward and has led to a significant increase of the number of plants that have been using filter press technology during the last years (see Figure 1).

By means of this technology, the soda recovery can be maximized considering that, besides the high dewatering degree, it is possible to carry out a deliquoring phase through the in-situ cake washing.



Figure 1. Example of filter press cake dry stacking with residual moisture lower than 30%

This versatility makes the filter press design and sizing phase critical. In fact, the technology and all the process variables are defined on the basis of the targets to be achieved. The result is a customized dewatering technology able to provide the required results at the lowest cost.

Therefore, from this point of view, careful attention must be drawn to the testing and piloting phases, which precede the elaboration of the commercial proposal and start from the study and characterization of the product to be treated, up to the filtration tests which are aimed at defining the process parameters.

The Diemme[®] Filtration R&D Laboratory of Aqseptence Group Srl has the right equipment to meet these needs. Two case studies are described below highlighting that products coming from different plants, despite a series of analogies, have substantial differences which determine a different filtration behavior. In view of this, different pressure filtration technologies must be used for the treatment of these products. Both cases refer to red mud filtration projects, for which Diemme[®] Filtration filter presses have been chosen.

2. Physicochemical Characteristics of Red Mud

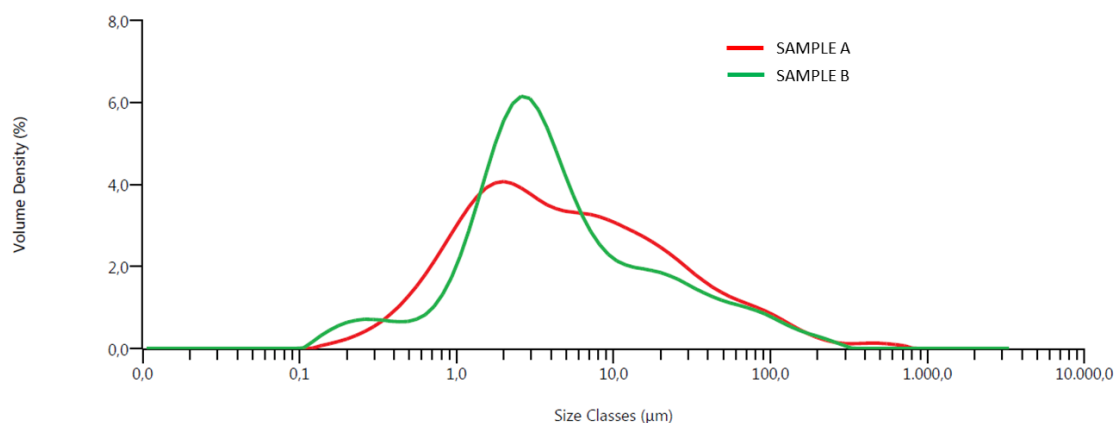
The below-introduced cases refer to red mud types coming from two different technologies. The main characteristics are reported in the following comparative Table 1.

Table 1. Slurries data.

	A	B
Slurry density (Kg/l)	1.40	1.39
Solid content (% w/w)	43.5	36.0
pH	12.9	13.5
Caustic content (g/l NaOH)	17.8	24.4
L.O.I. (% w/w)	15.7	11.4

The solid concentration slightly differs and is lower in sample B. However, in both cases, it is in line with the typical densities reached as U/F in the last thickener of the CCD. The same applies for the quantity of residual soda present in the liquor. [1, 5]

As for the particle-size distribution, the following are the graphs obtained through the analysis conducted by means of the laser granulometer (Figure 2, Table 2):

**Figure 2. Particle size distribution curves comparison.****Table 2. D-values comparison.**

	A	B
Dx (10) (µm)	0.804	0.953
Dx (50) (µm)	4.41	3.53
Dx (90) (µm)	43.0	36.2

The trends of the graphs are typical for this kind of suspension and show such a fine particle size such that, from a dimensional point of view, it is possible to consider both products as slurries with a mainly clayey or slime-clayey solid matrix. The two graphs are not overlapping, but can be perfectly compared, as these are included in the same dimensional range where the peak relevant to the main population is quite similar (20-30 µm) as proven by the values Dx(10) and Dx(90), which are very close.

Based on this information, the behavior could be similar also in terms of filterability. In fact, the particle size is one of the factors that most significantly contribute to the determination of the specific resistance of the cake and, as a consequence, its formation time.

However, consideration must be given to the fact that red mud is a very complex matrix, particularly for the solid phase. In fact, even if this is mainly composed by hematite in most of

the cases, it may contain different phases that could determine very different behavior from case to case.

Below, we are reporting the results of the XRF semi-quantitative analysis in terms of content of the main elements (Table 3) and, following, the XRD diffraction spectra with the qualitative analysis of the mineralogical phases (Figure 3).

Table 3. Elemental composition (main components).

	A	B
Al ₂ O ₃	27,2	16,8
Fe ₂ O ₃	26,5	48,1
SiO ₂	15,1	6,79
CaO	4,56	4,97
Na ₂ O	4,34	13,9
TiO ₂	3,04	4,36

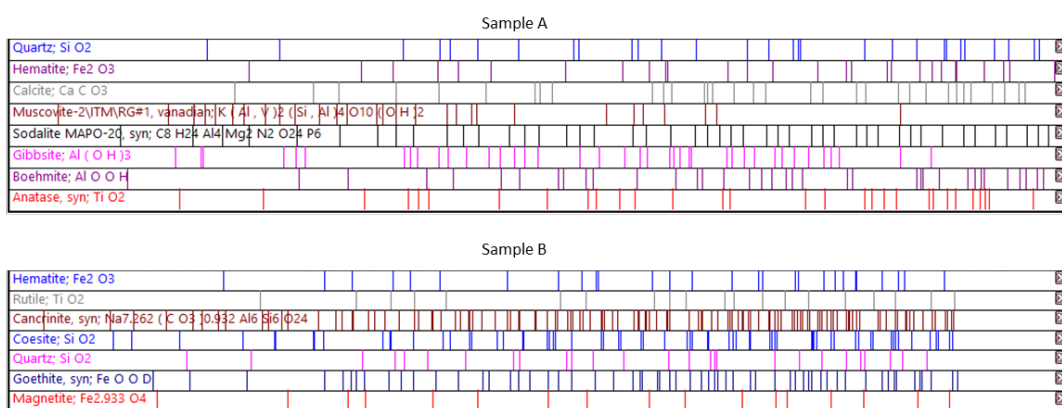
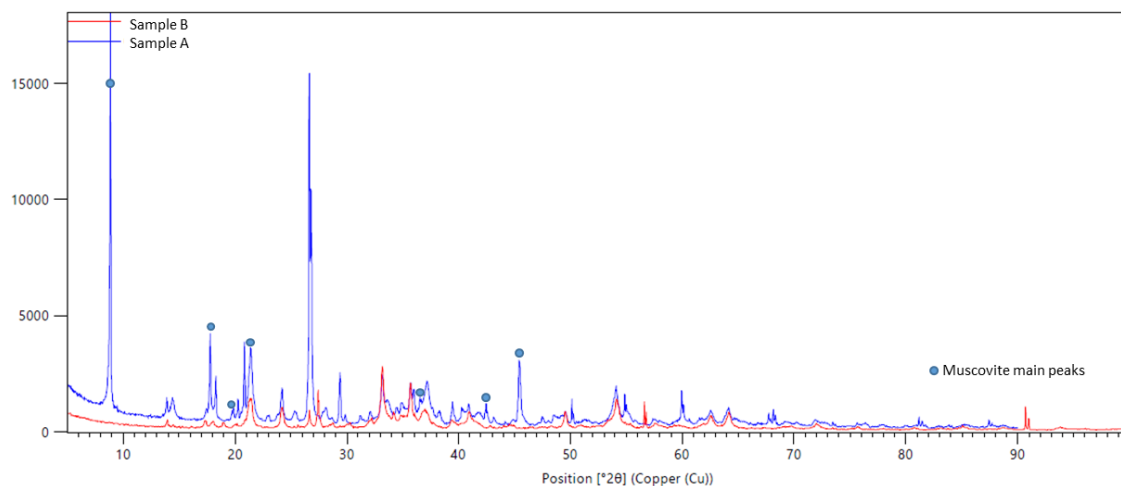


Figure 3. XRD spectrum and qualitative analysis.

Both analyses prove that there are substantial differences in the composition of the two slurries which are clearly due to a different bauxite ore. Product B has a higher iron content, in fact, hematite is the main component, whereas product A has a higher quartz concentration.

In terms of effects on filtration, the most interesting difference is the noticeable presence of muscovite in slurry A as shown in the XRD diffractogram. By means of Rietveld refinement, it is possible to quantify the content of this phase as 9% (without considering the amorphous). As it is known, muscovite is a phyllosilicate with a laminar structure that makes the cake packing less permeable with consequent increase of the average resistance.

The presence of these kind of phases (which are not present in slurry B) generally determines a medium or low-medium filterability, resulting in an increase of the feeding time and generating cakes for which the removal of liquid by cake blowing (hereafter referred to as desaturation) or displacement of the mother liquor by cake washing (hereafter referred to as deliquoring) phase requires quite extreme conditions. These factors are taken into account for a proper set-up of the testing phases conducted on the two slurries.

3. Filtration Tests

The filtration tests have been carried out by means of a bench scale filter press, like the one shown in Figure 4.



Figure 4. Filterpress bench unit.

The unit permits the simulation of the formation of a single cake, feeding the filtration chamber from a tank with compressed air in order to simulate the pump working pressure. It is equipped as to reproduce all the possible process configurations of an industrial filter press with variation of a series of parameters such as:

- Chamber thickness;
- Chamber type (with fixed or variable volume, with membrane);
- Working pressures (feeding, squeezing, blowing);
- Simulation of the consolidation phases (membrane squeezing), desaturation (cake blowing), deliquoring (cake washing).

The obtained results are perfectly scalable and the industrial equipment can be sized based on these. In order to define the performances that can be achieved with the two red mud types, we have carried out a series of tests simulating different process conditions. In particular:

- Filtration with fixed chamber and feeding pressure of 10-12 bar;
- Filtration with membrane chamber and final cake squeezing;
- Filtration with membrane chamber and squeezing with simultaneous final cake blowing.

Figure 5 summarizes the main results obtained with the two products. The graph shows that, in both cases, the use of a membrane filtration with final cake squeezing instead of the recessed filtration, leads to a quite modest gain in terms of residual moisture, about 1,5 percentage points. This situation changes if the cake blowing (desaturation) is added, as it entails a more significant gain for sample B (higher than 4 percentage points, compared to the filtration with recessed chamber), which makes this configuration interesting. This trend confirms what we predicted through the characterization results as the cake obtained with slurry B is more permeable and, therefore, the desaturation is more effective. For the same reason, the filtration time are significantly lower in case of slurry B.

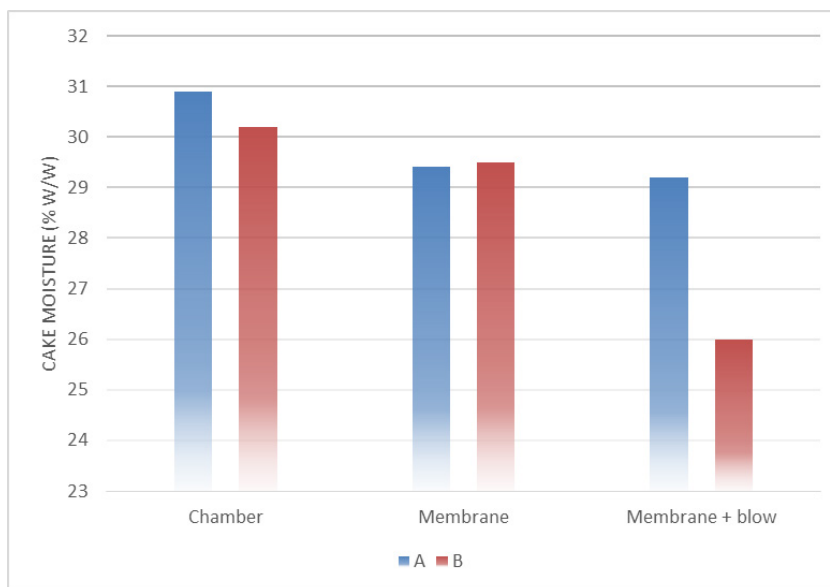


Figure 5. Filtration test results.

4. Filter Press Sizing

In order to size the filter presses, it is necessary to define the technology that most meets customer's need based on the required targets in terms of cake residual moisture, soda recovery, and solid throughput, considering the results of the filtration tests. In the presented cases, the behavior of the two red mud types turned to be very different and this is reflected in the equipment sizing and filter model selection.

The following are the final remarks in case of red mud A:

- The required residual moisture target (31% w/w) can be achieved by means of recessed filtration;
- The slurry shows a medium filterability and desaturation does not yield significant gains in terms of dryness content increase, because of the poor permeability of the cakes.

In view of these remarks and considering the input parameters provided by the customer, we selected a recessed filter model, with chamber thickness 35 mm and without cake blowing. The following pictures (Figure 6-8) show this installation and the dry-stack system.



Figure 6. Diemme[®] Filtration GHT filter press for red mud dewatering.



Figure 7. Red mud dry-stacking.



Figure 8. Refinery – Outside Building.

Final remarks are different in case of red mud B:

- This product has an high filterability, with rather quick feed time, that determines shorter filtration cycles, in comparison to case A;
- The lower specific resistance of the cake provides for more efficient desaturation, ensuring the achievement of a residual moisture $\leq 28\%$.

In this case, we have selected a filter press model with membrane plates and cake blowing.

5. References

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