Utilization of Decanter Centrifuge for Dewatering of Bauxite Tailings

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Abstract

One of the biggest challenges faced by the mineral industry is the need to do a proper tailings disposal, mainly associated to its moisture content. A lower moisture can be also a leverage to a rational usage of water resources, safe and efficient environment management. In Brazil, dewatering methods have been studied by the mineral industry, specially after the recent local tailings dam accidents. Different methods are avaliable worldwide, and decanter centrifuges are already an option for dewatering tailings on different operations, such as oil sands in Canada, gold ore in Peru, nickel in New Caledonia and also it is being tested for iron ore in Brazil. Regarding bauxite mines, it is estimated that tons of tailings are disposed every year, mainly in settling ponds or tailings dams. Since typical bauxite concentration consists basically in washing the ore and remove particles bellow 37 μm from the product, the bauxite tailings consist of ultra-fine kaolinite, what makes the dewatering operation even more challenging. In this scenario, the purpose of the current work is to analyze the bauxite tailings dewatering by decanter centrifuge, based on bench scale laboratory tests and semi-industrial pilot tests carried out with the tailings from bauxite processing fed by ore from Rondon do Pará, in Pará, Brazil.

Keywords: Decanter centrifuge, Dewatering, Bauxite, Tailings.

1. Introduction

In the mining industry, the scale of tailings production is large, and its storage and handling can be an environmental problem if not managed properly. As a result, tailings are disposed to wet every year in tailings dams or disposal ponds, which can present a high degree of risk and high implementation cost.

Dewatering methods has been studied, as well as new disposal options. There are several technologies available to accelerate the dewatering of tailings through the use of mechanical equipment that favor the solid-liquid separation and allow to reach a humidity such as to allow the disposal of practically dry tailings, further supporting the reuse of water and, thus, eliminating inconveniences and risks of disposal in dams.

Centrifuges, specifically like the decanter type, are versatile equipment and traditionally used in industries such as food, pharmaceuticals, petrochemicals, sanitation, among others. In mining, they are generally used when sedimentation by gravity is too slow or when you want to reduce the amount of water in the thickened phase.

2. Bauxite

Bauxite is a heterogeneous material whose occurrence in nature is characterized by a compound of one or more hydrated aluminum oxide minerals, silica, iron oxides, aluminum silicates, among others. About 90% of the bauxite produced in the world is used to manufacture alumina, the raw

material for aluminum metal. It is estimated that more than 90% of the refined alumina produced is destined to the production of aluminum metal. Other uses for bauxite include making abrasives, refractories, cement and bearing agents. [1]

According to data from the U.S. Geological Survey, 2020, the world bauxite reserves are 30 billion tons while the resources are estimated at between 55 and 75 billion tons. Its distribution is 32% in Africa, 23% in Oceania, 21% in South America and the Caribbean, 18% in Asia and 6% in others. In 2019, world bauxite production was estimated at 370 million tons. Brazil has a reserve of 2.6 billion tons and its production in 2019 was 29.0 million tons.

2.1 Bauxite Beneficiation

Typically, bauxite beneficiation has the following steps [2]:

- Comminution for handling and exposure of clay minerals;
- Disaggregation of clay minerals with water;
- Separation of clay minerals from the fraction of interest;
- Dewatering the fraction of interest;
- Dewatering of clay minerals and
- Disposition of clay minerals.

It is estimated that 25% of world bauxite production is made up of washed bauxite, with outstanding operations being: MRN (Rio do Norte Mining), Weipa (Rio Tinto), Paragominas (Hydro), Juruti (Alcoa) and Miraí (CBA). [2]

2.2 Bauxite Tailings

The fraction of bauxite that is not used in processing is rich in kaolinite and typically takes the form of a pulp diluted in water with a low concentration of solids. The disposal of this tailings in dams has always been a common practice in the mineral industry. However, the current scenario encourages mining ventures to seek alternatives to the use of dams. In this context, the investigation of dewatering alternatives and subsequent disposal of the bauxite tailings are in the center of most of discussions on bauxite processing.

Some of the practices for dewatering bauxite tailings are [2]:

- Natural dewatering: tailings are thrown into dikes and are allowed to settle naturally, while the clarified water returns to the process;
- Thickening dewatering: tailings are flocculated and thickened before being released, immediately recovering part of the water. The thickened pulp is allowed to settle in dikes and the clarified water returns to the process;
- Mechanical dewatering with thickener and centrifuges: in this option, before being fed to the centrifuges, the tailings are thickened, increasing the underflow concentration of solids, and the clarified overflow from the thickener returns to the process;

- Mechanical dewatering with thickener and press filters: just like the previous method, before being fed to the filter press, the tailings are thickened, increasing the underflow concentration of solids, and the clarified overflow from the thickener returns to the process.

Depending on the adopted form of dewatering, it is possible to dispose the tailings as pulp or solids. The options evaluated are:

- Disposal in dikes: the tailings are pumped to a dike where it is allowed to settle. These dikes can vary in size, depending on their useful life and the desired final solids concentration;

- Backfilling of exhausted strips: the tailings are returned to the pit after ore mining and covered by the release of the capping of the next strip;

- Disposal in piles: the dewatered tailings are piled in a specific area, with constant monitoring of the stability of the pile.

3. Tailing Treatment Routes

Currently, the vast majority of tailings are discharged by natural sedimentation in tailings dams. The environmental impact of these large settlement lagoons is huge, not to mention the area requirements and risk involved. This disposal method also results in the loss of process water due to evaporation, which can be critical in areas where water is short in supply. [3]

In a tailings dam, solids are settled by sedimentation, so the force on the sediment is the Earth's natural gravity. However, when the presence of fines in the tailings is between 90 – 100% and the percentage of solids in the pulp is approximately 30%, the sedimentation speed is very low, due to the high viscosity that this pulp presents. In these cases, dewatering becomes an interesting option. Bauxite tailings fits in this case, given that in its processing process, all the fine fraction fed is considered tailings.

The use of mechanical equipment to promote dewatering favors the solid-liquid separation in such level that makes it possible to reach a tailings moisture low enough that enables a dry disposal, further, increasing the reuse of water and, thus, eliminating inconvenient risks in dams. This means that tailings do not need to be stored in ponds. There is a reduction in infiltration rates and in the area used, in addition to the elimination of long-term environmental liability.

The dewatering operation may also, in the future, enable the creation of co-products from bauxite tailings, in civil construction areas and as agricultural inputs. Examples of potential applications: cement production, road construction, brick production, soil quality improvement, among others.

The solid-liquid separation methods, or, more specifically, dewatering, can be classified in two ways [3]:

- By the relative movement of the phases, where the solid moves through the liquid at rest, which is called sedimentation, it’s most striking example is thickening, or the liquid moves through a stationary phase, as in the drainage of stacks or silos, or even in sieves. Considering the tailings from bauxite processing, the use of sieves does not allow the drying of the solid tailings to a moisture low enough that allows its stacking.

- By using auxiliary separation forces, such as filter presses and decanter centrifuges, the object of this study.

3.1 Dewatering by Decanter Centrifuges

In a decanter centrifuge, slurry is continuously pumped through the feed tube and enters the centrifuge through the feed chamber inside the rapidly rotating cylinder. The Figure 1 show the cross-sectional view of the interior of a decanter centrifuge.

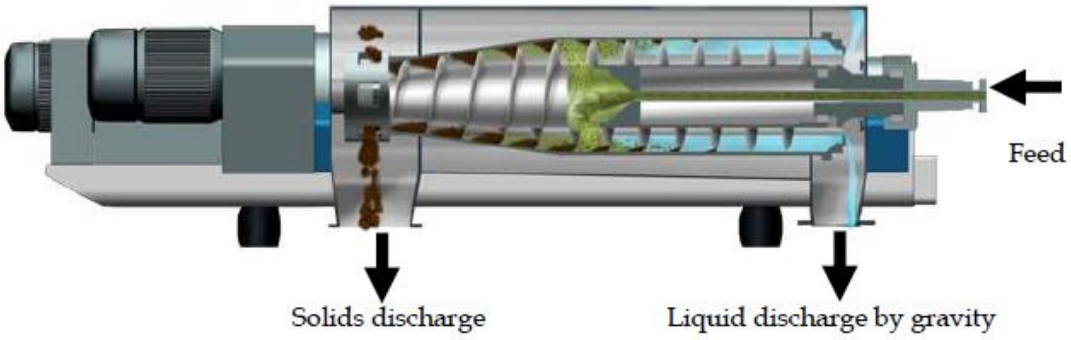

Figure 1. Solid bowl decanter centrifuge. Flottweg SE, 2015

Centrifugal force causes the pulp to form a ring inside the cylinder. As the density of solids is greater than that of liquid, solids settle on the inner wall of the rotor. To remove solids, a helical screw rotates inside the cylinder with a differential speed (positive or negative) in relation to the cylinder and transports the accumulated solids towards the solids discharge.

The cylinder is tapered towards the solids discharge from the centrifuge so that, at a given moment, the solids leave the liquid zone and pass to the shore area. Here, the solids drain further until they are discharged through the holes by centrifugal force. As the diameter of the solids discharge section is smaller than the diameter of the liquid discharge section, liquid (clarified) can only exit from the liquid discharge side of the cylinder. By adjusting the position of the liquid outlet it is possible to adjust the flooded diameter and the dry area. [4]

4. Laboratory and Field Tests

In order to assess the best route for dewatering the tailings from bauxite processing, laboratory and field tests were carried out, the results of which are explained below.

4.1 Laboratory Tests

The Spin Test is performed in order to predict the effectiveness of the decanter centrifuge in separating the liquid and solid phases of a given pulp. It is done with the pulp samples being placed in transparent and graduated tubes, which are inserted in a support that will undergo rotation with speed between 1000 and 4000 rpm, and times from 1 to 30 minutes, simulating the effect of a centrifuge. Each 50 ml tube should contain 40 g of sample. Figure 2 below shows an example of equipment to perform the Spin Test.

Figure 2 – Spin Test. Author, 2018.

In October 2013 during the Alumina Rondon Project, the Flottweg company performed a Spin Test with a sample of Rondon's bauxite. Figure 3 and Figure 4 shows the result of some tests carried out by Flottweg with the Rondon bauxite tailings.

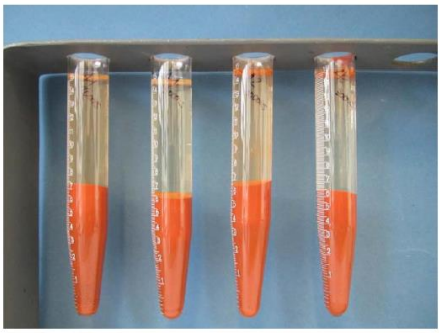

Figure 3 - Sample A of the Flottweg Spin Test. Author, 2018.

Figure 4 – Results of Spin Test. Author, 2018.

According to the results of tests carried out in 2013, Rondon Sample A bauxite indicated that dewatering by centrifuge is recommended. Tests indicated that the resulting dewatered tailings will be approximately 70% solids.

The Spin Test can simulate the densification of solids, which occurs in the cylindrical part of the centrifuge, but cannot simulate the dewatering, which occurs in the conical section of the centrifuge and, therefore, does not provide performance guarantees by the supplier necessary to ensure the process bauxite dewatering. This is only obtained with Pilot Tests which will be highlighted in the next item.

4.2 Pilot Plant

A pilot plant was designed to generate information that could be used in a future design of full-scale facilities.

The objective when designing, building and operating a pilot plant is to obtain information about a particular process. The flowchart of the pilot plant is showed below in Figure 5, and we have a step of crushing, scrubbing, screening and finally classification. After this step, we start with the dewatering process when the classification overflow is fed to the centrifuge. The solid discharge is our tailings, and water in the liquid discharge return to the process.

Based on the data obtained, we can determine if the process is technically and economically viable, as well as establish the optimal operating parameters of such process (scale up), for the subsequent design and construction of the plant on an industrial scale.

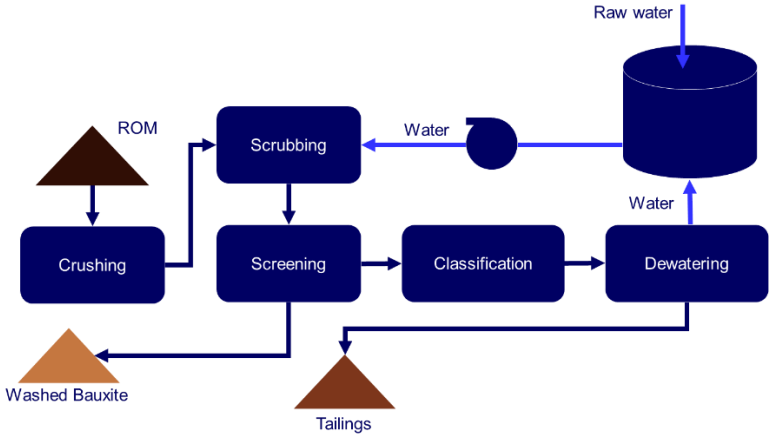

Figure 5 – Flowchart of pilot plant.

Finally, in order to obtain more reliable data regarding the use of the centrifuge to dewater bauxite tailings, CBA promoted the installation and operation of a pilot dewatering plant at its unit in Itamarati de Minas-MG. The equipment tested was the 2500 A4 Decanter, supplied by Andritz, with a bowl diameter of 457 mm, 100 kW of installed power and weight of 6.0. Figure 6 shows the installed equipment during the pilot test.

Figure 6 – Pilot centrifuge by Andritz. Author, 2019.

4.3 Pilot Tests

About 100 ton of material were sent from Rondon do Pará-PA to Itamarati de Minas-MG and were fed to the pilot plant during two weeks on December, 2019, and all tests work were made with fed the centrifuge with the hydro cyclone overflow.

The centrifuge parameters during the pilot test presented the best results were 2000 G; 2807 rpm bowl speed; 12 rpm differential speed; and 15 m³/h of power supply. Figure 7 is an example of the underflow % solids when the tests work with this best parameters.

Figure 7 - Cake with 65%-69% of solids. Author, 2019

The limitations of the pipeline did not allowed the stable operation above the 15 m³/h, and the differential speed was change during the tests according the results, finally fixed in 12 rpm.

As the settings on the motor speed were limiting the differential speed in 9 rpm (minimum) with 2000G, we have made one test with 1500 G - keeping all parameters as constant. As the solids % underflow decreased, we kept the 2000 G for the further tests.

4.4 Results

For determination of total solids content in the underflow, overflow and in the feed of the centrifuge a moisture analyzer was used. The results of the test are in the Figure 8.

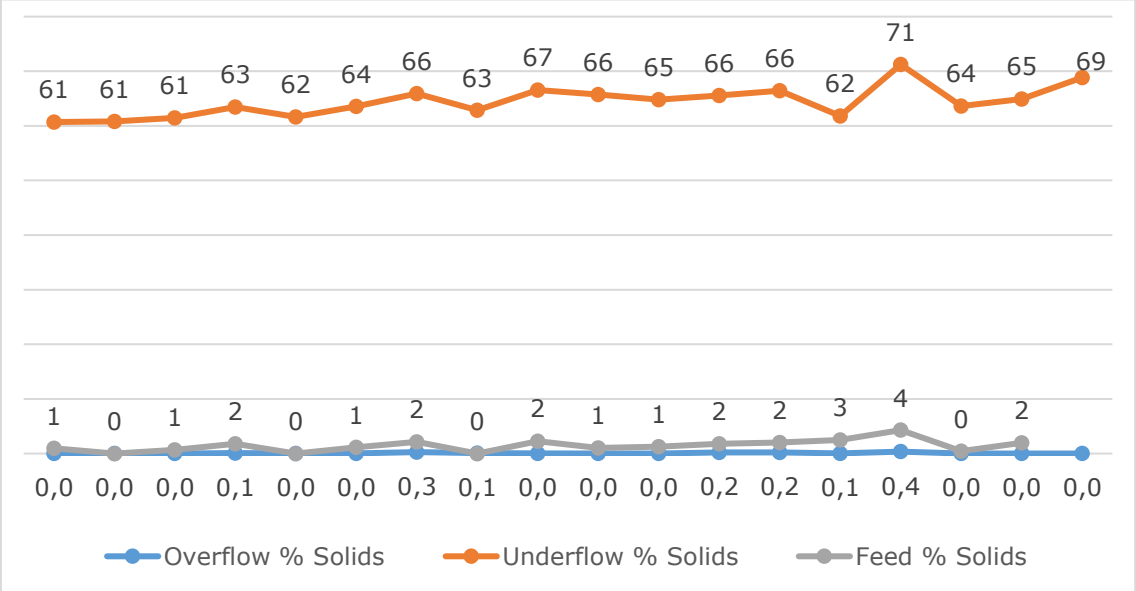

Figure 8 - Results of solids concentration in centrifuge flows.

Even without the addition of polymer, the solids recovery in the equipment during pilot testing was around 90%, and with the addition of polymer, it reached close to 100% solids recovery.

5. Conclusions

For the Rondon bauxite tailings, the pilot test pointed out that it is possible to obtain a 68-70% solids in the cake obtained by dewatering the tailings with a centrifuge, validating the predictions obtained in the laboratory test.

The moisture reached during the test is enough to handle the bauxite tailings and dispose it back is the open strips, validating the disposal strategy of the Rondon Project.

6. References

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