Reference Description Alunorte

Hyperbaric Bauxite Filtration – New ways in Bauxite Transportation

Alunorte, Brazil

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Abstract

At Barcarena in northern Brasil, Alunorte has commenced processing of bauxite from the newly developed Paragominas mine. The challenge was to transport the bauxite over a distance of 260 km to the existing alumina refinery in Barcarena. Several options for transportation were studied. This resulted in Alunorte's decision as the first company in the world to grind the bauxite, mix it with water and transport the suspension containing approx. 50% bauxite in a pipeline to the refinery. The next problem to be solved was to dewater the very fine bauxite to the low residual moisture content required by the existing refinery using the Bayer Process. Several options were investigated, the most promising being filter presses and hyperbaric disc filters. The decision was made in favourof the hyperbaric disc filter due to the continuous operation and lower investment costs. This resulted in the largest installation of hyperbaric filters in the world with a total filtration area of 840 m². This paper gives an overview of the whole investment project starting from the equipment selection process, the basic design of the plant, installation and start-up at the beginning of 2007.

Introduction

Alunorte is one of the world leading alumina refineries, located in Barcarena, north of Brasil. For its "expansion2" it processes bauxite from the newly developed Paragominas mine, which is located 260 km away. The area between the mine and the refinery lacks adequate infrastructure for transporting large quantities of ore.

The technique of transporting minerals or ores in a pipeline is not generally a new technology. Pipelines for copper or other kind of ores can be found in several locations from Chile to China. Although the technique is not new it has never been applied for bauxite over such a long distance of more than 200 km.

A railway line is well proven fortransporting ores, but the investment costs per km are 4 to 6 times higher than for a pipeline. Also with regard to operation and maintenance costs, the railway system is far more expensive. In addition the impact of a pipeline on the environment is much lower.

Alunorte studied several options. The final decision was made to grind the bauxite, mix it with water and transport the suspension containing approximately 50% bauxite in a pipeline to the refinery, being the first alumina refinery in the world to use this kind of transport solution. For this challenging task the bauxite must be ground to a specific grain size. Flow velocity, pipeline design and slurry concentration require a specific range of bauxite grain size.

The next problem to be solved was how to dewater this very fine bauxite suspension from a moisture content of 50 % to the water content acceptable for the Bayer process i.e. 12 to 15%. Several options were investigated. The most promising ones were filter presses and hyperbaric disc filters.

Although the filter presses had slightly lower equipment costs, the decision was made in favour of the hyperbaric disc filters, due to continuous operation, better dryness and lower overall investment costs. The sizing required the largest ever installation of hyperbaric filters with a total filtration area of 840 m².

Dewatering of finely ground Bauxite

The bauxite of the Paragominas mine proved to have a very specific grinding behaviour. This resulted in a grain size distribution with a d50 typically less than 50 microns. Especially the fraction <10 µm is an important challenge for the mechanical filtration process following pumping.

The dewatering of fine concentrates is in general an important unit operation in the commercial treatment of minerals. With decreasing grain size, the dewatering becomes more and more difficult due to increasing filtration resistance.

For such a fine grain size distribution, combined with the high throughput requirement of several hundred tons/hr filtration, vacuum filters or centrifuges were not considered from the early beginning.

The following Table 1 summarizes typical grain size, chemical composition and slurry concentration of the resultant bauxite slurry:

Chemical Composition of Bauxite	Grain Size classification		Slurry concentration %DS	Slurry / hr for expansion 2
	d_{50}	d_{25}		
Al_2O_3 approx. 50%	< 50 µm (approx.)	< 10 µm	approx. 50%	Up to 960 tons

Table 1: Typical Bauxite characteristics of Paragominas Bauxite after 242 km of pipeline transport

Vacuum filtration, although well known for several industrial applications, has the disadvantage that the filtration resistance as a result of such fine particles is too high for a reasonable filtration process.

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For filter cake drying by vacuum or blowing, Schubert's theory [5] states that a relative degree of saturation arises (assuming next to ideal conditions):

$$\frac{S - S_r}{1 - S_r} = f \frac{p_c}{\varepsilon\eta\left(1 - S_r\right)} \frac{\left(\Delta p - p_k\right)t_2}{h_k^2}$$

S	Degree of saturation
S_r	Residual degree of saturation
p_c	Cake permeability
p_k	Capillary pressure
t_2	Dewatering time
Δ	Porosity
η	Viscosity
h_k	Cake thickness
p	Pressure

Expressed in simple terms, as the residual moisture content of the cake drops, the higher the effective pressure difference becomes (pressure difference applied minus the cake capillary pressure). Vacuum filtration with a pressure difference of 0,5 to 0,7 bar therefore has its limits.

Centrifuges have limits too. Especially the ultrafine particles (< 10 µm) cannot be separated with high G-forces and would be lost with the centrate.

This equation shows that the filtration rate in terms of throughput per unit area of filter increases with the square root of the differential pressure. Increasing the temperature and thus reducing the Poiseuille[4] and others suggested one way to increase the specific throughput was by increasing the differential pressure across the filter medium. Placing a vacuum filter inside a pressure vessel allows much higher pressure differences. Adaptation of Poiseuille´s equation [4], which is usually applied to filtration, shows the following:

$$\textbf{Filtration rate} = \left(\frac{2\Delta p W_r}{\mu r t}\right)^{\frac{1}{2}}$$

Δp	Pressure drop across filter
W	Weight of dry cake per unit volume
μ	Viscosity of liquid (filtrate)
r	Resistance of filter media
t	Cake formation time

Viscosity of the filtrate would be a theoretical option, but an enormous amount of steam would be required to heat up such high quantities of material.

Practical investigations done on the installed base of Vacuum Filters (VF) and Hyperbaric Filters (HBF) have been performed by Andritz and are summarised in Figure1 below:

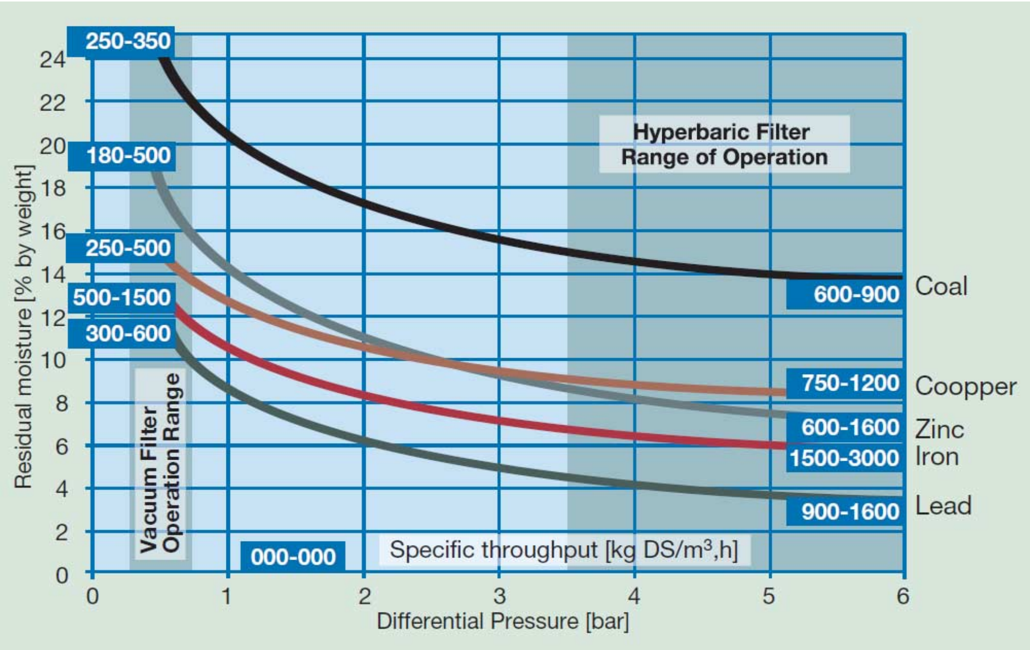

Figure 1: Practical experience with vacuum and hyperbaric filtration (6)

Equations (1) and (2) are principally confirmed by Figure 1. Both the residual moisture and throughput increase significantly if the pressure difference is increased.

Using cake blowing technology, the filter press can basically deliver similar dryness values. For smaller throughputs and coarser material filter presses can be an economic alternative. Both systems – hyperbaric filtration and filter presses had been tested and finally the HBF technology was selected by Alunorte due to:

- very high specific throughput resulting in a reasonable number of units
- high pressure operation (applicable pressure difference up to 5,8 bars) for filtration giving excellent dryness
- continuous operation
- lowe roverall cost

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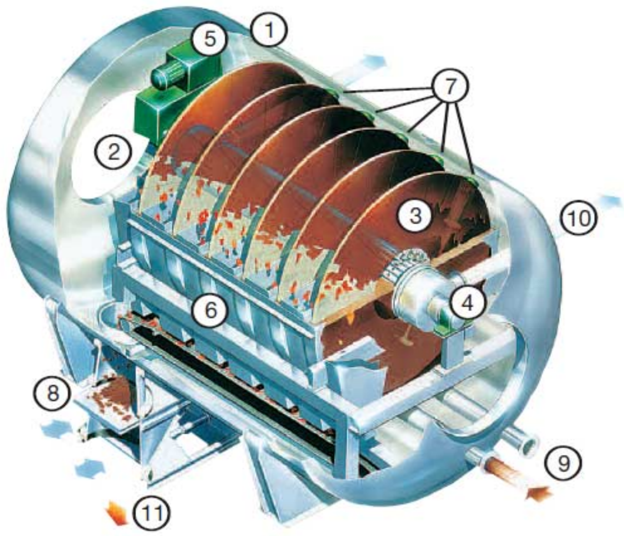
Filtration Equipment HBF

The principal procedure of Andritz Hyperbaric Filtration (HBF) is illustrated in Figure 2.



1 Pressure vessel
2 Manhole
3 Filter disc
4 Control head
5 Filter drive
6 Filter feed trough
7 Agitators (option)
8 Discharge device
9 Compressed air supply
10 Filtrate drainage
11 Cake discharge

Figue 2: Main components of an Andritz Hyperbaric Pressure Filtration Unit (HBF)

The suspension is pumped into a filter trough (item 6) preferably by a helical rotor pump with variable speed drive. For suspensions that tend to settle an agitator can be installed there as an option.

Approx. 50% of the discs consisting of 20 segments are submerged.The filtration itself is done by the same steps as in a vacuum filter. It consists of the sequence cake forming –dewatering -snap blow. Due to the 4 to 5.8 bar overpressure in the pressure vessel, dewatering is very efficient.
After cake forming and dewatering (drying) the cake is discharged by the snap-blow device and transported via a chain or belt conveyor towards the discharger.

The discharge is one of the keys to this technology. The discharger must not only carry the load of the cake (approx. 2 – 3 tons/cycle), it must also support the load resulting from the pressure in the pressure vessel. This load can be more than 100 tons under normal operation conditions. Two gate valves open alternatively.

All the components undergo the highest quality inspections. Special emphasis is laid on the sealing system and to the design of the knife gate. The principal cycle of discharging is shown in Figure 3. Minimum cycle time is approx. 1 minute. It is controlled automatically by time switch or level probe in the upper/cake receiving chamber.

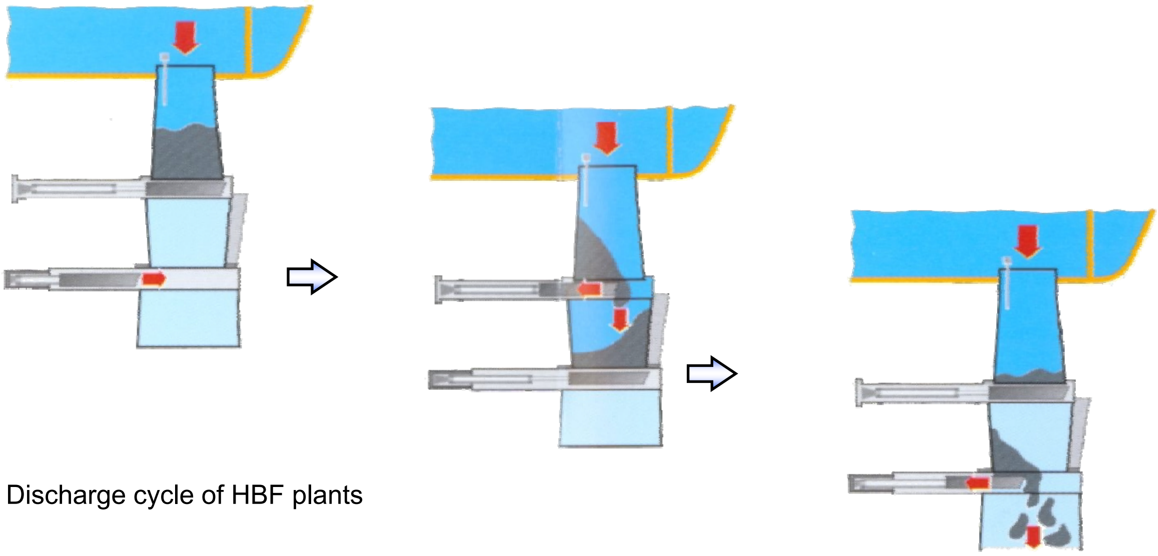


Figure 3: Discharge cycle of HBF plants

The production capacity of the filter depends on the parameters:

- selected pressure in the vessel
- rotating speed of thefilter shaft
- speedof slurry feed pump

These parameters can be set by the operator. The whole process runs automatically and needs only supervision from the operators in the remote control room. Hourly inspections of the filters are recommended. Details of this technology have been published in [2, 3, 4].

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Bauxite Filtration Plant at Barcarena / Brasil

Figures 4a and 4b depicts the bauxite filtration plant of Alunorte do Brasil at Barcarena (expansion 2). It is comprised of 5 Andritz HBF units, each one having a filtration area of 168 m2. 5 further units are under construction at the moment and will be put into service during 2008 (expansion 3). The pipeline has already been built to include the production of expansion 3.

To avoid sedimentation a minimum flow velocity is required in the pipeline. Thus their operation is at present intermittent. Each storage tank can hold approx. 8 hours of pipeline slurry, which is afterwards pumped to an intermediate tank. This minimizes the distance between the slurry pump and the HBFs.

Figure 4a: 5 units each 168 m² filtration area, operation pressure 5.8 bar

Figure 4b: HBF Bauxite Filtration plant at Alunorte do Brasil in Barcarena

Figure 4c: Andritz HBF 168 m² (inside view)

Figure 4d: Bauxite slurry tanks

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Operation experience project implementation

Only 17 months after the project start, the plant received suspension for the first time. After this the pipeline capacity was ramped up continuously and the whole system (mine-pipeline-filtration) achieved round the clock operation in March 2007.

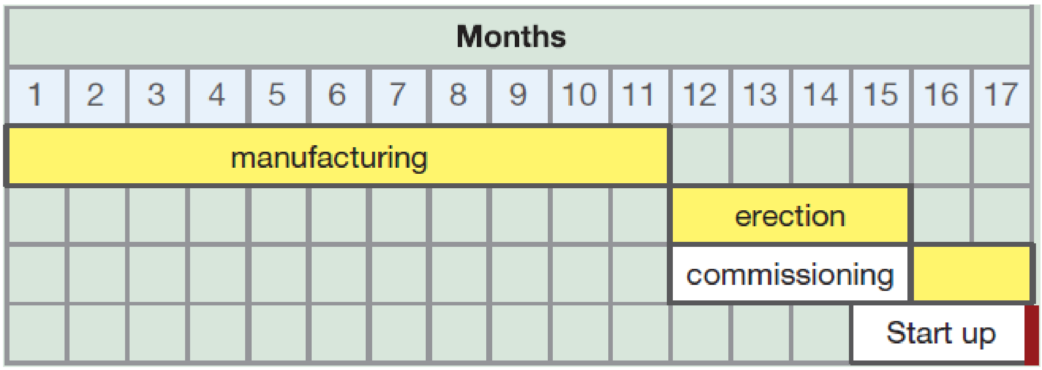

Figure 5: Time schedule of HBF project (schematically)

Operational results summarised	
Throughput per filter:	up to 140 t/h DS depending on grain size
Residual moisture:	12 to 15%
Air Consumption:	approx. 25 to 40 Nm^3 / m^2 filtration area
Filtrate load:	approx. 3 to 10 g/L
Filter cloth Type:	SEFAR 2ALU4

Essential parameters for the performance are:

- slurry concentration
- grain sizedistribution
- filter cloths
- selected operation pressure

The best combination of these parameters is left to the experience of the operator. Each parameter influences the results interms of throughput and residual moisture individually and can be influenced by the operator to a certain extent.

Conclusion

The successful practical application of hyperbaric filtration technology to the new field of bauxite filtration has enabled a new way of bauxite transport. Continuous operation combined with high applicable pressure are the main advantages of this technology. The installation of a pipeline in the Amazon region has shown that it is not only cheaper than conventional rail transport, but has the added benefit that the environmental impact is minimized. This technology may open up an economic way to exploit mines in remote areas.

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