CONCENTRATION OF BAUXITE FINES VIA GRAVITY CONCENTRATION

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Abstract

Companhia Brasileira de Alumínio (CBA) has a preparation plant at Itamarati de Minas, MG. This plant washes two different kinds of bauxite ore, one originated from the laterization of gnaisses and another from amphybolites.

Both ores have the same behaviour in the coarser size fractions but behave differently under 42# Tyler. In these small sizes, gnaissic ores are rich in quartz and amphybolitic ores are rich in iron and titanium bearing ores.

The unit operations are: scrubbing of the feed in drum scrubbers, desliming in cyclones, and screening of the scrubbed bauxite in high frequence screens (42# Tyler) – the +42# product is a final concentrate. The -42# fraction is deslimed in two stage cyclones and goes to a fines preparation circuit of gravity concentration in Reichert spirals complemented by magnetic separation of the light product from the spirals.

The research work, including mineralogy, process development, batch tests and pilot plant tests, is described and compared to the actual results in the industrial circuit.

key words: bauxite preparation, gravity concentration, Reichert spirals.

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INTRODUCTION

As far as we know, bauxite preparation practice only exists in Brazil. In the other producing countries, the richest ores are directly fed to the refinery plant. Depending on the silica / available alumina ratio of the ores, poorer ores can be fed to especially designed refineries.

In Brazil, bauxite preparation is routine:

- Mineração Rio do Norte, at Oriximiná (PA), dresses bauxite via scrubbing, desliming in a complex cyclones circuit, and dewatering in vacuum filters (Reis, 2004);
- Mineração Santa Lucrécia, at Monte Dourado (PA), had a circuit to prepare ceramic grade bauxite via heavy media separation in dwp (Sampaio & Neves, 2005);
- Companhia Brasileira de Alumínio (CBA), at Poços de Caldas (MG), uses scrubbing, optical sorting and desliming in cyclones;
- CBA, at Itamarati de Minas, MG, scrubs, screens, deslimes, and uses Reichert spirals and magnetic separation to recover bauxite from fines;
- Mineração Rio Pomba, at Mercês (MG), uses jigs to separate the coarse silica;
- CVRD is starting-up a new project at Paragominas (GO), using autogenous grinding and desliming in cyclones.

This paper describes CBA's development of the fine bauxite circuit at Itamarati de Minas.

CBA has a strong commitment to sustainable development in mining and metallurgy. This considers the best recovery in minerals preparation as well as the minimal generation of tailings to be disposed in the environment. The effort to recover the bauxite values contained in the fines is mainly due to this commitment.

ITAMARATI DE MINAS DEPARTMENT

CBA belongs to the Votorantim Group and operates a mine and preparation plant at Itamarati de Minas, MG.

The plant started operations in 1992. It works with two types of ore. The first one is the product of laterization of gnaissic rocks; its main contaminants are silica and clay-minerals. The second one comes from the weathering of amphybolitic rocks; its main contaminants are Fe_2O_3, TiO_2 and clay-minerals.

In 1992, the flowsheet consisted of:

- primary crushing to reduce ore under 5";
- primary scrubbing;
- primary screening in 1" and ¼" sieves;
- secondary crushing of +1";
- secondary scrubbing of the crushing product and of the –1+¼";
- secondary screening in ¼" (the oversize of this secondary screening is a final product);
- -¼" fines are screened in 14# (1.2 mm) (the oversize of this screening is another final product and its undersize is a tailing).

Mass recovery for a concentrate with 42% available alumina was 43.5%, metallurgical recovery was 61%, and monthly production was 30,000 tons.

In 1996, the sieves for primary screening were changed from 1 to 2" and from ¼" to 14#. Secondary screening started to use the same sieve. Tertiary screening was eliminated.

The undersize of these operations (-14#) started to be deslimed in 26" cyclones. The cyclones underflow started to be sent to high frequency screens with 48# (0.3 mm) sieves.

Mass recovery increased to 48.5% and metallurgical recovery, to 67%. Monthly production increased to 34,000 tons.

In the beginning of 1999, 26" cyclones were exchanged for 15" cyclones of different design. Underflow rate (or 48# screens feed) increased, demanding three additional screens. By this time the 48# sieves were exchanged for 40# (0.35 mm) sieves. Mass recovery increased to 55.5% and metallurgical recovery, to 75%. Monthly production increased to 45,000 tons.

Until 2000, both types of ore – amphybolitic and gnaissic – were dressed together. This is correct, as their behaviour is similar till the size of 40#. The differences start under this size – the contaminants for both ores are segregated at this fraction: the amphybolitic ore is diluted by iron and titanium ores whereas the gnaissic ore is diluted by quartz (Oba, 2000).

If an effort was to be made on the bauxite recovery in the finer sizes, the two ores had to be processed individually. Tests indicated that an increase in bauxite recovery was feasible for the amphybolitic ore – iron and titanium minerals can be separated by magnetic separation. But, as this operation is an expensive one, gravity separation in shaking tables and concentrating spirals was tested. It showed to be useful and led to a cheaper configuration where only the bauxite concentrate (a minor portion of the feed flow) was sent to the high intensity magnetic separator.

The gnaissic ore could be separated by the same process, but, as its quartz content is very high, the increase in available alumina grade is not significant, and the results are not interesting.

A pilot plant was erected at the industrial plant. Both ores (one by one and together) and different circuit configurations were tested: with and without previous desliming, with two and three spirals stages, with internal recycling to the spirals, different splitting of the products etc. Feed flow rate to the spirals was varied to measure their actual capacity.

As results were obtained, they were jointly analysed and discussed by the EPUSP and CBA teams. Testing evolution and changes in circuit configuration were then defined.

Figure 1 shows the pilot plant which was operated for 3 months. It had one 6" cyclone, two or three Reichert spirals (depending on the circuit configuration), a high intensity wet magnetic separator and auxiliary equipment such as pumps.

This experimental campaign has provided the necessary information for the industrial circuit project.

It has also provided an important insight about the intrinsic variability of the bauxite ores. Mining in the Zona da Mata region is done at the top of the high mountains where laterization occurred. Deposits are small and the quality of the ore varies from one another. It also varies inside the ore body, in horizontal as well as in vertical directions.

The pilot plant operation allowed us to detect such a variability, to measure it, and to be able to design a robust preparation plant, i.e., a set of equipment with extra capacity reserve, able to absorb such a variation. This means that all the equipment must have extra capacity to be able to deal with extreme variations in feed characteristics.

Figure 1 - pilot plant

AMPHYBOLITIC ORE PREPARATION

Based on these conclusions, the industrial circuit was complemented: now, the undersize of the high frequency screens is sent to a battery of 6" cyclones. They are designed to classify – d_{95} of 250# (0.06 mm) – extracting the fines with high reactive silica content which make the slurry viscous, worsening the densitary separation performance. The cyclones underflow is processed in two concentrating spirals stages. Each stage extracts a heavy minerals product (a tailing). The light and the medium products of the first stage are reprocessed in the second stage. The medium product of this stage returns to the first stage and the light one is sent to the high intensity wet magnetic separator.

This way, a small part of the feed flow is sent to the more expensive magnetic separation. The medium magnetics are recycled in the same equipment. Non magnetics – the final product – are dewatered and added to the coarser concentrate. The magnetics are joined to the heavy product from the spirals, dewatered in a spiral classifier and stored.

Mass recovery of the full plant reaches 60% when working with the amphybolitic ore and proper feed rates. Metallurgical recovery goes up to 90% in such a situation. In ordinary operation, alternating the two ore types, mass recovery reaches 59%.

Figure 2 shows the industrial plant. Figure 3 shows the pile where the heavy product of this circuit is stacked. Figure 4 shows the present flowsheet.

Figure 2 - industrial plant

Figure 3 - heavy minerals concentrate pile

USE OF TAILINGS

The described work applies only to the amphybolitic ore. When the plant operates with it, the tailings produced are the 15" overflow, the -40+65# fraction, the 5" overflow, the heavy product and the magnetic product.

When operating with the gnaissic ore, the tailings are the 15" overflow, the -40+65# fraction, and the -65# fraction.

Characterization studies on the heavy and on the magnetic products have shown high concentrations of iron and titanium (about 62% Fe and 28% Ti) plus gibbsite and magnesite.

Cantagalo is a neighbour region where Portland cement is produced. The high grade limestone used demands clay and hematite additions for proper clinker composition.

Our basic idea when developing this circuit was to return the heavy minerals concentrate to the digged mine bottom and to bury it before mining reclamation. But then tests were carried out at the Portland cement plant, substituting both clay and hematite for this product.

Positive results were found: gibbsite and goethite behave the same way as clay and hematite. Unexpected benefits came from the hitherto unknown behaviour of the titanium ore. It acted as a fluxant for clinker, lowering clinkerization temperature.

This allows the furnace to operate at a lower temperature, saving fuel oil, increasing the refractories' life, decreasing the number of maintenance stops and thus increasing the number of productive hours. This leads to significant economy in the cement plant.

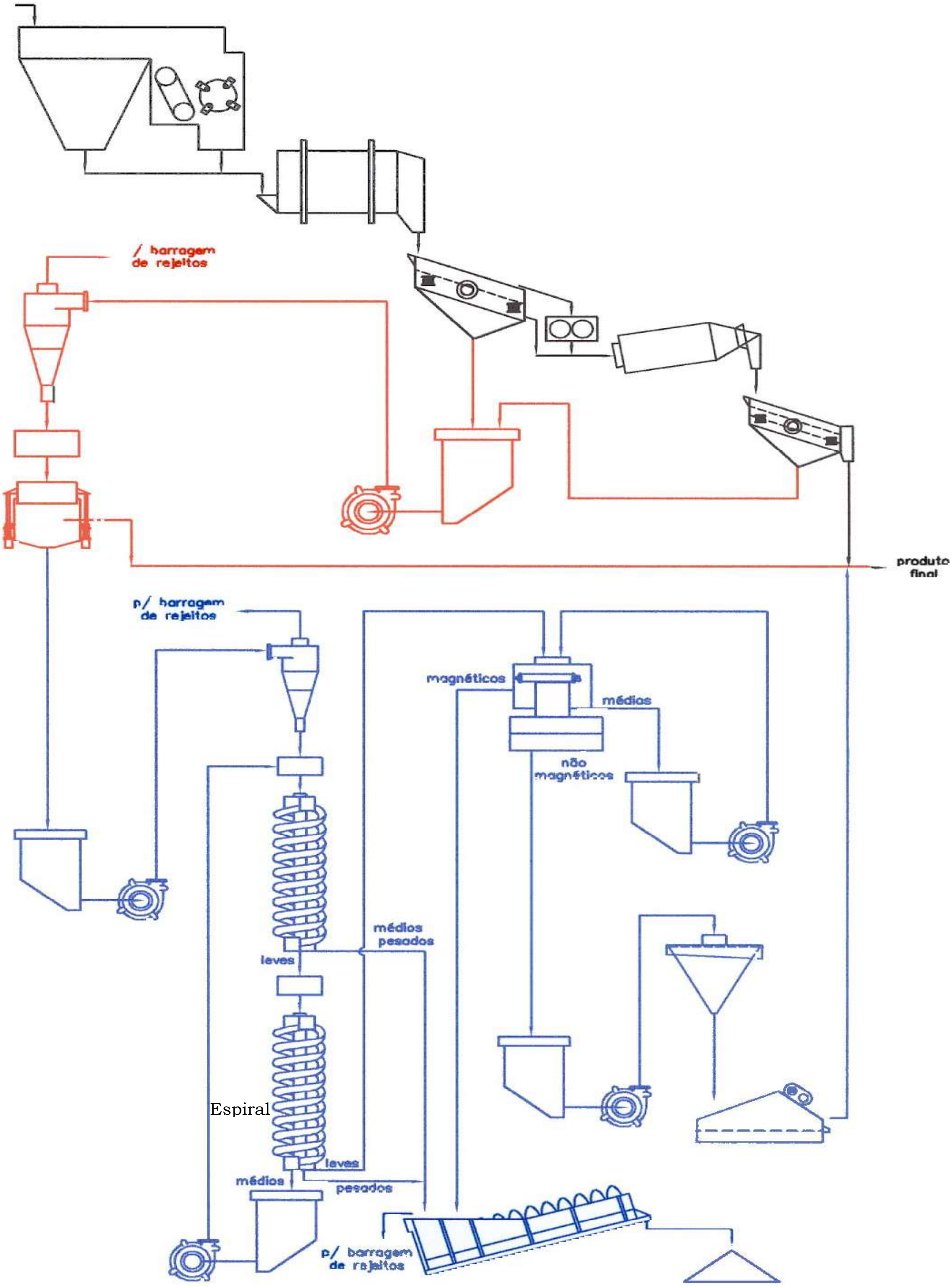

Figure 4 - today's flowsheet

The use of this tailing avoids the disposal of 25,000 tons per year into the tailings dam.

The other tailings at the moment are the overflows of the 15 and 6" cyclones. These are very fine materials, about 94% -200# (0.074 mm). They are composed of gibbsite, kaulinite, hematite, pseudorutile and grenalite. There is then potential for its use as raw material for ceramics.

Initial tests consisted in separating the -5 μm fraction and in preparing 9 pressed briquettes. They were burned to 900, 950 e 1000 ºC, yielding a very nice red colour and presenting good mechanical strength. Contraction, water absorption and porosity gave satisfactory results.

Next step was the extrusion testing of the full overflows (not only the -5 μm fraction). The pure product is not good, but blended with plastic clays led to miniatures such as those shown in figure 5.

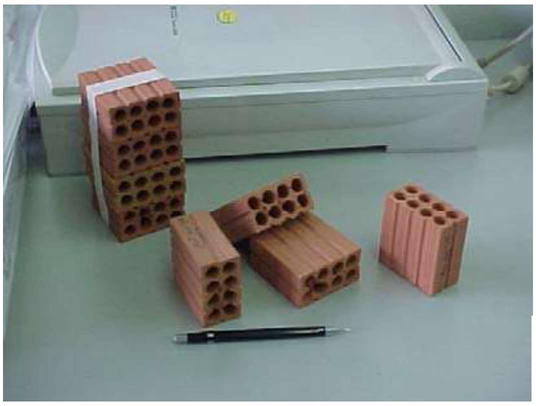

Figure 5 - extruded brick miniatures

CONCLUSION

The use of gravity concentration process, of classification in cyclones, and of magnetic separation proved to be feasible for the bauxite from CBA's operations. Plant production and available alumina increased as a result of their application.

This is an unpublished development, as far as we know, and we are very proud to present it.

As an associated result, tailings were transformed in by-products. This is especially welcome as our initial purpose was only to decrease the intensity of the environmental impact caused by tailings disposal.

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