DESIGN, SIMULATION AND OPERATION OF THE MILTONIA BENEFICIATION CIRCUIT

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Abstract

Miltonia was the first bauxite plant in the world to integrate the beneficiation process with a long distance slurry pipeline operation. The mine and bauxite plant are located in the State of Para, west of Amazon region in Brazil, whereas the alumina plant is installed 230km away, near the state capital Belém.

As an integrated process the specifications for the beneficiation plant product were selected on the basis of pipeline operation, as well as on the dewatering system. It thus resulted in a strict size distribution for the ground bauxite.

This paper describes the main aspects of process selection and equipment design, as well as the successful method for predicting the plant performance based on pilot plant testing and mathematical simulation of the process. Main aspects of industrial operating experience are also addressed.

1. Introduction

The relative concentrations of gibbsite, iron oxides and clay determine the chemical grades of the laterite layers and attribute their fundamental classification as bauxite. However, the nature and form of the iron oxides and clay co-determine their economic potential, because they affect processing characteristics.

A typical profile of the Miltonia deposit comprises layers of Top soil and Clay Overburden (CAP), Nodular Bauxite (BN), Ferrous Laterite (LF), Crystallized Bauxite (BC - main ore), Amorphous Bauxite (BA), followed by mottled clay at the bottom. In between the two latter layers is a transition zone designated as BCBA.

All the layers of the Paragominas laterites and bauxite have spaces with loose clay, which should be separated out to attain acceptable reactive silica grades for the refinery. But onnly separating the clay still leaves portions of the laterites with grades of iron oxide and reactive silica unsuitable for the refinery. Furthermore, these layers of the deposit have poor performance such as slow mud settling, low liquor clarity or low mud compaction. Consequently, a combination of selective mining and beneficiation is required for upgrading chemical quality and guaranteeing process performance of the natural laterites.

The application of pipeline transport and dewatering stages require controlled comminution and slurrying the bauxite for pumping.

Good quality bauxite suitable for Alunorte refinery or a new refinery with similar technology should meet the following criteria:

- Tri-hydrate, Gibbsitic bauxite;
- Available Alumina > 47%;
- Reactive Silica < 5%;
- Insignificant chemical contaminants;
- 100% extraction of the available alumina;
- Desilication in about 60 minutes at 145-155°C;
- Red mud settling rate greater than 8m/h;
- Liquor Clarity better than 200mg/L;
- Mud Compaction better than 35% solids.

Milling for the pipeline system replaces milling the bauxite in the refinery. However, the specifications for pumping determine a finer grind than that actually needed by the refinery. The pipeline design is based on producing slurry with the following specifications:

- 100% < 0.30 mm (48# Tyler);
- 90-95% < 0.21 mm (65# Tyler);
- 42-47% < 0.045 mm (325# Tyler);
- 52% solids concentration in mine site storage tanks.

2. Beneficiation Flow-Sheet Development

Vale has studied beneficiation and milling of the Miltonia bauxite and developed a process flow-sheet for removing loose clay and reducing the washed bauxite to a fine grain for transport. These studies began with the screening stage, followed by contributions from a series of advanced investigations, from the variability program and the pilot plant trials.

2.1 Initial Screening

The screening phase had two objectives:

- To determine the feasibility of indiscriminately mining the complete laterite profile, and postponing selection of the bauxite to the beneficiation plant;
- To determine the cutting parameters for physically separating the clay fraction from the natural rock mass.

Vale tested milling the ore before classification and high-intensity magnetic separation as means of recovering the high alumina portions of BN and LF, either separately or mixed with other laterites.

The screening trials determined mass and metallurgical recovery for different laterites and bauxite. Process trials determined the industrial performance characteristics of individual ore types and combinations.

All the lithological types have the same chemical constituents, occurring in different proportions, different minerals, different states of crystallization and different degrees of development of the concretionary mass. Consequently, the chemical and mineralogical profiles change down the lithological sequence, and the changes are reflected in the quality and refinery performance of the beneficiated product that could be recovered from each type.

Excess iron oxides could be rejected by classification and high intensity magnetic separation after milling, but classification after milling causes low metallurgical recovery of alumina from BC, because fine gibbsite is rejected along with the clay. Therefore, it was necessary to process BC and BN/LF in separate streams, with different flow-sheets, to maintain high recovery of BC and upgrade the BN/LF. Even so, a blended final product does not meet refinery grade specifications. The residual reactive silica brought with the BN portion puts the product above the specification limit, and material recovered from the BN/LF may adversely affect refinery performance.

Each of the five lithological types, BN, LF, BC, BCBA and BA, has its own grade attributes, but all contain significant amounts of fine-particle clay that contain reactive silica. The clay fills holes and spaces between (and within) the harder concretionary masses. Most of it however can be removed by crushing and washing to disperse the clay in water, followed by classification to discard the fine fraction. Clay not liberated by such beneficiation is usually less than half the total quantity and closely enveloped by the concretionary mass, or it is part of its crystal structure. The gibbsite particle size distribution extends below 0.037 mm, overlapping the clay. Therefore the choice to separate ore and waste at 0.037 mm is a compromise that simultaneously maximizes the metallurgical recovery of gibbsite and removal of reactive silica.

The bench scale beneficiation of BC samples, which produced these results were precursor of the industrial plant design. These consisted of the following sequence of processing and analysis:

- Crushing to 95% less than 1-inch;
- Homogenization and splitting out portions for standard chemical and size-by-size mineralogical analysis;
- Drum scrubbing, followed by wet screening at 400# to classify product and reject - screen oversize is product;
- Grinding the product to meet the pipeline particle size distribution, and
- Standard chemical analyses of the fractions for Total Alumina (TA), Available Alumina (AA), Total Silica (TS), Reactive Silica (RS), Fe_2O_3 , TiO_2 and Loss of Ignition (LOI).

2.2 Advanced Test Work and Off-Site Pilot Plant Tests

The technical characterization studies, including the variability program, involved bench scale and pilot plant tests undertaken in Brazil at the Vale Technical Center - CDM, and CETEC - a public institution, together with pilot plant tests conducted at the Centro de Investigaciones Mineras Y Metalurgicas - CIMM, in Chile. After the screening, the test work concentrated on BC. The scope of the tests included:

- Determining physical, chemical and mineralogical properties of the ore;
- Establishing parameters for flow-sheet development;
- Confirming performance in the conventional low temperature Bayer Process, and
- Examining the ore variability across the deposit.

The physical, chemical and mineralogical investigations characterize the BC ore as follows:

Physical Characteristics

- Specific gravity: 2.6 t/m^3
- Bulk density: 1.4 - 1.5 g/cm^3
- Angle of repose: 35^o at 10% moisture
- Bond Work Index: 12 to 19 kWh/t.

Chemical Characteristics

The beneficiated products obtained from samples used for characterization were analyzed for AA and RS, as well as the total oxides and LOI that account for 99% of the mass. Some samples were analyzed for a wide range of minor constituents to detect the presence of elements that are potentially deleterious in the Bayer process. As an example of the full range of chemical constituents. Table 1 presents the complete analysis of a typical bulk sample of BC from Miltonia 3 deposit.

Table 1. Typical chemical grades of Miltonia 3 Bauxite (BC)

Composite	Assay (%)
TA	51.3
AA	41.2
TS	10.4
SR	9.3
Fe_2O_3	10.9
L.O.I.	25.0

The potentially deleterious elements, such as organic carbon, phosphate or zinc are found in insignificant quantities.

The chemical grade of Miltonia 3 (M3) bauxite compares favorably with that of the Trombetas bauxite currently used at Alunorte, and with the range of grades complied from a literature study of other bauxites produced around the world. In contrast, another significant part of the Miltonia deposit, known as Miltonia 5 (M5) has a lower alumina grade but this bauxite can be mined in a proportion with M3 bauxite to produce a blend that meets the refinery specification.

2.3 Pilot Plant Tests

Preliminary pilot plant programs included a combination of classification and grinding of the slurried bauxite. Washing, classifying and grinding the bauxite to the pipeline specification was carried out in a four-step process using drum scrubbers, classification and two stages of grinding in rod and ball mills. Alternatively, employing semi-autogenous grinding, SAG milling, for part of the post-crushing size reduction offered an opportunity to combine washing and part of the size reduction in the same equipment, thus removing a step of the process. Choosing the second route would simplify the industrial plant and reduce the amount of equipment required. Both routes were tested in pilot plants, using two similar samples of BC.

2.3.1 CDM Pilot Plant: Rod-Ball Mills

The CDM plant processed approximately 20 t of BC, simulating the operations of an industrial plant based on scrubbers and a rod and ball mill combination.

R.O.M. (Run of Mine) bauxite was sized for mill feed using a jaw crusher followed by a 25 mm vibrating screen, which recirculated oversize through the crusher.

Product selection was conducted in a drum scrubber, screens and hydrocyclones. Scrubber discharge was classified on a 3 mm screen, and the screen undersize was reclassified through two stages of hydrocyclones, with the underflow of the primary hydrocyclone feeding the secondary. The overflow of both hydrocyclones, calibrated to cut at 0.037 mm, constituted the tailings. Together, the screen oversize and underflow from the secondary hydrocyclone made up the product.

Resizing the product to meet the pipeline specification was made in two stages. A single pass through a rod mill preceded finishing in a closed circuit ball mill. The mills were set up in a reverse circuit, both discharging to the spiral classifier closing the ball mill. This set-up allows rod mill discharge meeting the product specification to by-pass the ball mill, while combining new and recirculated oversize as the classifier underflow, which feeds the second stage grinding in the ball mill. The classifier overflow accumulated as product.

This pilot plant successfully made a product that reproduces the grade improvements obtained by bench-scale beneficiation.

2.3.2 *CIMM Pilot Plant: SAG – Ball Mill*

Vale and consultants combined experience from other projects with the results of the bench-scale tests to design the alternative concept for bauxite beneficiation and grinding. CIMM used 200 t of BC to test this concept and demonstrate that a SAG mill is appropriate to substitute and combine the scrubber and rod mill in the original design concept.

In comparison to the CDM tests, the feed to the CIMM plant was coarser, and a crusher was not used. Large blocks in the sample were broken by hand to make 150 mm the top size of the 6-foot SAG feed, adequate for the pilot mill and close to the top size to be produced by the full-scale secondary crusher. Product reject classification took place on the SAG discharge and a closed circuit ball mill was used to finish the product.

CIMM tested the SAG mill under different conditions and demonstrated that the SAG performed the required operations. The complete circuit successfully obtained a beneficiated product within the physical and chemical specifications.

An outstanding result from the CIMM pilot plant program was that the pebbles removed from the SAG mill showed relatively low grades of RS, together with a higher grade of AA. Based on such results, a SAG open circuit was adopted that is the crushed pebbles were deviated to the ball mill circuit, instead of recycling back to the SAG mill.

A thorough analysis of the pilot plant program was carried out with the JKSimMet mathematical simulator, which was used to mass balance experimental data, as well as fit mathematical models.

The results obtained in these pilot plants indicate very similar performance for both beneficiation routes, with respect to beneficiation and mass recovery.

Chosen Beneficiation Route

The pilot plant test results did not indicate an obvious technical preference for plant design, and the equipment in both concepts was of proven reliability. Therefore, choice of a flow-sheet became a matter for economic engineering based on the costs of implementation, maintenance and operation. On this basis, an engineering study resulted in choosing the SAG-Ball Mill combination, because it was less expensive. The complete washing and milling plant could be built in a single building and there were almost 100 less items of equipment to maintain, in each 4.5 Mtpy production line. The resulting beneficiation flow-sheet, defined for engineering, was composed of standard comminution and classification operations by using sizers, SAG mills and ball mills, with screens and hydrocyclones to classify products and tailings; and to prevent over grinding.

Both SAG and ball mill were designed on the basis of mathematical models fitted in the pilot plant program. All other process equipment such as hydrocyclones and crushers were also designed by the JKSimMet simulator, as shown in Figure 1.

2.3.3 *CETEC Pilot Plant and Pipeline Filter Design*

The CDM and CIMM pilot plants were not controlled to produce slurry exactly meeting the final pipeline specification, which was still under development when they were run. In fact, the products from both were finer than specification. Consequently, a third pilot operation was mounted at CETEC, in Belo Horizonte with the specific purpose of producing three slurry samples all meeting the upper size limits of the pipeline specification, and varying the minus 325# content from 35 to 45% to test the effect of fines variation on slurry dewatering. The sample used for this operation was also BC, and the test circuit was set up using a rod and ball mill combination. This operation also produced slurry finer than specification, with between 50 and 55% passing 325#, except when the upper size limit was relaxed to allow the complete PSD curve move up. Nevertheless, the samples were used to develop a worst-case conceptual design for a dewatering filter plant.

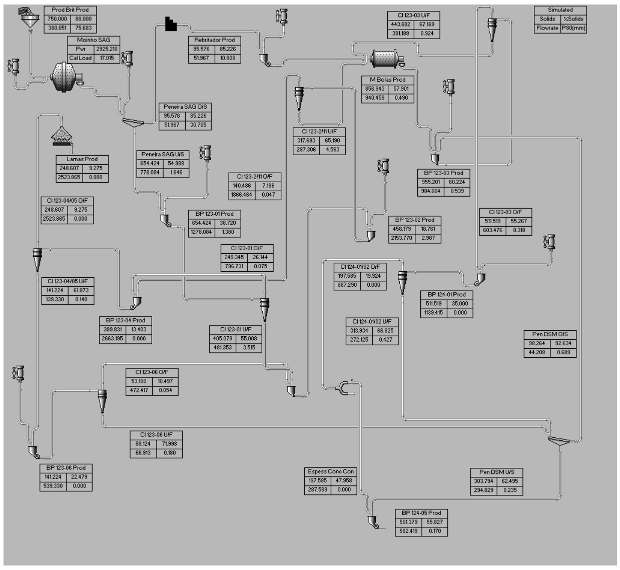

Figure 1. Process simulation

The laboratory filter tests showed that fines less than 20 microns, in excess of 20%, and slurry concentration below 50% solids, reduce filtration rates and consequently increase the plant size. Simultaneously, the pipeline specifications require fine grinding, therefore operation of the beneficiation plant will have to strike a balance between partially conflicting demands. The conflict was resolved, provided that the industrial plant could produce slurry that meets the target particle size distribution curve, which was a consensus between the pipeline and filter plant engineers. This aspect did not affect the choice of mainstream milling equipment but raised questions with respect to engineering the control and efficiency of the ball mill classification systems, which are to be employed in the industrial plant.

2.3.4 *Paragominas Pilot Plant*

The open questions have been addressed by operating a SAG-Ball Mill route Pilot Plant at Paragominas. The plant was organized so that different arrangements and different types of auxiliary equipment could be tested. The Paragominas Pilot Plant was commissioned at the end of June 2004, with the following objectives:

- Consolidate the grinding process established for the Miltonia industrial plant;
- Calibrate mathematical model components related to the process;
- Assemble a mathematical model that represents the entire industrial grinding circuit;
- Analyze the variability of bauxite samples from different parts of the deposit;
- Simulate process conditions and alternatives in order to achieve product specifications;
- Generate representative samples for other studies including slurry transport and dewatering, tailings thickening and drying, and bauxite characterization;
- Continued operation may be used to train people to operate the industrial plant.

3. Industrial Circuit

Miltonia industrial plant comprises a SABC-O circuit, that is a Semi-Autogenous Mill followed by a Ball Mill and Pebble Crusher, the latter operating under an open circuit configuration. A brief description of the Miltonia circuit follows.

3.1 Process Description

The industrial process comprises four stages, as follows:

- Crushing and stockpiling,
- Coarse grinding and desliming,
- Fine grinding,
- Dewatering and final screening.

Water recovery and tailing disposal is also included in the industrial area.

Essentially, the Miltonia flow-sheet comprises a sequence of fragmentation and classification steps for removing the clays and achieving the particle size distribution specifications. The clay is the main source of reactive silica. Accordingly, the primary fragmentation carried out by two-staged sizers and a SAG mill exposes the clay locked in the voids of the gibbsite mass. The SAG discharges onto a horizontal vibrating screen, whose undersize follows a sequence of two classification steps carried out in hydrocyclone nests. The combined fine fraction of these stages is deslimed in hydrocyclones, whose overflow is then thickened and pumped to the tailing dam. The coarse fraction of the desliming stage is dewatered before going to the final product of the plant. The coarse fraction of the first two stages of hydrocyclones is pumped to the ball mill circuit, which also processes the SAG screen oversize. The latter is first crushed in an impact crusher.

The ball mill circuit comprises a conventional direct closed configuration with hydrocyclones, whose overflow is dewatered and screened before going to the final product storage tanks. The final screening is conducted in DSM screens for assuring the top size specification.

A combination of hydrocyclones and thickeners is used to recover the water for re-circulating to the plant. The tailings are pumped to the tailing dam, where drying areas are surrounded by earth dykes, in order to build up in layers which partially fills the valley adjacent to the plant site. Process flow-sheet is presented in Figure 2.

3.2 Crushing and Stockpiling

Run-of-Mine bauxite is dumped by trucks onto a hopper that feeds the primary crusher. Accordingly, the primary MMD sizer was designed to crush the ripped, run of mine ore slabs from approximately 1.2 m to 300 mm. A secondary stage of MMD sizer further reduces the top size to a nominal range of 200-150 mm.

Crushed ore is conveyed by a 42-inch wide conveyor belt to a blending stockpile adjacent to the crushing plant. The 200 kton blending stockpile equipment includes a 2800 tph stacker that piles the crushed bauxite in a windrow pattern, and a 2500 tph capacity bucket wheel reclaimer. An auxiliary system provides the alternative of by-passing the stockpile, that is the secondary crusher product may be diverted to the grinding plant.

3.3 Coarse Grinding and Desliming

Reclaimed crushed bauxite is conveyed to a silo designed for a 24 minute capacity. A variable speed apron feeder withdraws bauxite from the silo to feed a 26´ x 16´ SAG mill, which is driven by ring gear/pinion and a 6500 hp variable speed motor. The main operating parameters of the SAG mill are:

- Nominal feed rate: 754 t/h (dry);
- Load volume: 30%;
- Ball Charge: 13% (maximum);

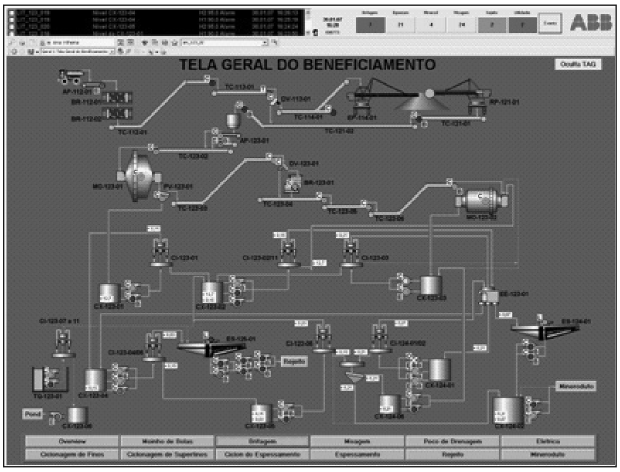

Figure 2. Miltonia process flow-sheet

- Speed: 65-80% of critical value;
- Grate aperture: 65 mm (slotted).

SAG mill operates under a relatively high dilution (55% solids) in order to provide a low residence time for the fines in the mill chamber. Such a procedure is meant to avoid over grinding at the SAG mill, as it directly affects the overall mass recovery of the plant.

The grate aperture and open area was selected for providing a relatively high slurry flow through the SAG mill, as well as rapidly discharging the pebbles from the mill chamber. The grate aperture therefore prevents the pebble build up in the mill chamber. Following the results from the CIMM pilot program, the pebbles are crushed in a Hazemag impact crusher, whose product is conveyed to the ball mill circuit, instead of recycling back to the SAG mill feed.

The SAG mill thus provides the necessary flexibility in order to cope with feed variations. This is particularly useful in periods where the stockpiled material is by-passed.

The SAG mill discharges onto a 8´x 20´ horizontal vibrating screen. The screen oversize fraction (> 12 mm) is conveyed to the 350 hp impact crusher, whose product (P_{80} = 12 mm) is conveyed to the ball mill circuit.

The screen undersize is classified in two consecutive 26-inch diameter hydrocyclone stages, underflow of the primary hydrocyclone feeding the secondary. These hydrocyclone stages are together named “Fines”. The nominal cut size of first stage is 65# (0.21 mm), whereas in the second stage the cut size is 100# (0.15 mm).

The combined overflows of the “Fines” are pumped to the desliming stages, which consists of two 10-inch nests of hydrocyclones, both designed for a 0.037 mm cut size. These two hydrocyclone stages are together named “Ultrafines”. The combined overflow of the “Ultrafines” is pumped to the tailing thickener, while the second stage underflow is pumped to the final product screening.

The -12.0 + 0.21 mm fraction from the “Fines” is pumped to the ball mill circuit for fine grinding.

3.4 Fine Grinding

Crushed pebbles together with the – 12.0 + 0.21 mm fraction are fed to a single fixed speed 21´ x 32´ ball mill driven by a 9600 hp motor. The main operating parameters of the ball mill are :

- Ball Charge: 34%;
- Discharge mode: overflow;
- Speed: 74% of critical value.

The ball mill operates in a closed circuit with a nest of twelve 26-inch hydrocyclones, named "Classification", operating at a nominal cut size of 0.21 mm. The combined underflow is returned to the ball mill feed, whereas the combined overflow is pumped to the dewatering stage.

3.5 Dewatering and Final Screening

The dewatering stage consists of a nest of 10-inch hydrocyclones and a thickener, the latter fed by the overflow of the former. The underflow of the dewatering hydrocyclones, together with the thickener underflow gravitates to DSM screens, which were designed to guarantee a 48# (0.30 mm) top size to the final product.

As the ball mill circuit was designed for producing a 90-95% passing 0.30 mm, the DSM screen oversize is recycled to the ball mill, while the undersize fraction is pumped to storage tanks located near the final pipeline pumping station.

The percent solids of the final product is controlled by the dewatering hydrocyclones, together with the residence time in the thickener, for achieving the targeted 52% figure.

The beneficiation plant is well equipped with instruments and automation. The distributed control system is assessed by plant operators in the control room using a state-of-the-art display panels.

4. Commissioning

The industrial circuit was commissioned from late 2006 when the crushed stockpile was accumulated. Following a testing period, bauxite was first fed to the SAG mill in December 2006. A comprehensive and careful commissioning scheme was designed for both Miltonia mills in order to cope with energy limitations occurring by that time. Such a procedure included a long operation in an Autogenous (AG) mode for the primary mill, together with a relatively low ball charge in the ball mill. Mill manufacturer representatives closely assisted this operation period.

Once the new energy line was fully implemented, a different scheme was adopted for the SAG mill. Accordingly, it was decided to step increase the plant throughput to the limit of the AG mill mode.

While the plant throughput was gradually increased, a number of valves, instruments and control loops were progressively commissioned. Manual operation was the main mode for operating the plant, as more diluted pulps were necessary in order to maintain the flow velocity throughout the various pipes throughout the plant.

Since the initial operation, it was clear that the DSM screens were not performing accordingly. A combination of pipe blocking and feeding problems resulted in low efficiency of fines, thus affecting the final product particle size distribution. The relatively large amount of fines in the oversize also contributed to a size degradation, as such a fraction is pumped back to the ball mill feed.

A number of alternatives were tested for the DSM operation and feeding scheme. The combination of vertical feeding and a coarser wired mesh resulted in a steady operation in this part of the plant.

After achieving a 500 t/h level, the SAG mill started to be step filled with steel balls, each step comprising an equivalent of 2% in the mill volume. Pumping and hydrocyclone operation throughout the plant were adjusted as the pulp percent solids were adjusted to ensure conformity with the designed values.

Surveys were carried out regularly throughout the plant in order to assess the performance of selected equipment, such as hydrocyclones and mills, as well as the overall performance of the process.

The experimental data and information were processed at the JKSimMet simulator which was then used to simulate each specific stage of the industrial circuit. The fitted models were particularly useful in the commissioning stage.

5. Plant Operation

The two main variables affecting a SAG mill operation are feed size distribution and ore resistance to breakage. As the variability program indicated, the M3 bauxite types are relatively homogenous in terms of resistance to impact breakage. Therefore the feed size distribution is the main operating variable for the Miltonia SAG mill. Moreover, such a variable affects the entire plant performance as it drives not only the SAG throughput but also the partition between coarse (pebbles) and fine fraction.

The recurring problems encountered with the stacker and reclaimer equipment result in frequent feeding of the SAG mill directly from the crushing plant product. In such periods, the irregular size distribution propagates through the SAG mill operation, although this is partially compensated by varying its rotating speed. Hence, a relatively coarse feed requires higher mill speeds for increasing the impact breakage mechanism, which provides the massive amount of energy necessary to break the large fragments within the mill chamber. Conversely, a relatively fine feed requires lower mill speeds to decrease the potential damage to balls and liners, as results from a charge deprived of bauxite fragments. The latter situation is potentially dangerous for the impact crusher, as broken balls may pass through the grate and by-pass the magnet installed above one of the conveyor belts.

As the feed size distribution also affects the SAG mill discharge size distribution, the main issue in controlling the plant performance is thus to adjust the operating condition for all "Fines", "Ultrafines" and "Classification" stages for accommodating the SAG mill discharge characteristics. Accordingly, a SAG finer product increases the solids throughput to the "Fines" and "Ultrafines" stages. Conversely, a coarser discharge drives a relatively higher amount of solids to the ball mill circuit, thus requiring fine tuning at the "Classification" stage.

Overall the classification stages, such as SAG screen and various hydrocyclone nets operate within the designed parameters under controlled conditions. Pumping is mainly operated under automatic mode, controlled by level sensors and variable speed motors. The final product screening has been addressed in detail in thorough pilot plant testing programs, as well as comprehensive testing with high frequency screening. The results indicated adequate performance for the latter, which will replace the existing equipment in the near future.

Plant operation data is regularly used to fine-tune the mathematical models which are used for optimizing the process.

6. Operating Experience

The innovations included in the Miltonia industrial plant required a high degree of commitment to a young team of operators. The fast growing learning curve is a reality at Miltonia, and this has translated into increasing production as well as achieving high levels of safety.

The managerial staff as well as the supervisors and operators are well aware of cause-and-effect chains in plant operation. This is particularly useful in coping with feed size variation and its effects throughout the plant. By maintaining the average plant mass recovery within the nominal value reflects the ability of the Vale team to control the plant operation. The relatively low variation in such indices also indicates the capacity of the whole team to understand the process and react accordingly.

The plant has been operating well, even though it still requires fine tuning. The main issues is to avoid size degradation of the final product when the high frequency screens are not installed at the industrial plant.

Following the requirements of the dewatering system at Barcarena, the minus 0.020 mm fraction is now assessed and controlled at the Miltonia industrial plant. Adequate ball size distribution and controlled circulating load in the ball mill circuit are the key for achieving the specification for the minus 0.020 mm fraction of the final product.

7. Conclusions

The operation shows that bauxite can be produced within specifications and targeted production in the Miltonia industrial plant. The combination of controlled fragmentation and stepped classification provides a feasible route for preparing adequately ground bauxite to pipeline transportation.

Mathematical simulation proved to be a reliable and robust instrument for predicting the plant performance, thus useful for both designing and optimization stages.

The managerial and operating team achieved higher standards of both safety and production, mainly due to their commitment and knowledge.

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