Investigating the Processability of Low Grade Bauxite Available in Jamaica

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Abstract

Jamalco's bauxite reserves have deteriorated in quality mainly due to a decrease in the available alumina, and an increase in the reactive silica, boehmite, goethite and phosphorus content. This has resulted in decreased alumina recovery, and increased production costs resulting from increased caustic loss, increased scaling on heat exchange surfaces, and decreased efficiencies. Low temperature alumina refineries, such as Jamalco, must determine their ability to process deteriorating bauxite quality to remain viable. This paper explores the results of extensive laboratory experiments investigating the processability of some of the lowest grade bauxite available in Jamaica and its impact on bauxite residue settling and chemical additive consumption. The impact of variability in reactive silica, aluminous goethite and boehmite content is explored.

Keywords: Bauxite residue, Reactive silica, Aluminous goethite, Boehmite, Hydroxamated flocculants (HX)

1. Introduction

Jamalco is a low temperature alumina refinery in Clarendon, Jamaica processing Jamaican bauxite. Good quality bauxite, sometimes referred to as Jamaica-1 bauxite (boehmite < 3 % and < 30 % of the iron mineral as goethite), has been mostly depleted [1]. Remaining bauxite stores consist of higher boehmite and goethite content, coupled with increased reactive silica and corresponding decreased available alumina content. These types of bauxites present many processing challenges and refineries must explore adaptations to the processing of these more difficult bauxites. The practical approach would be to blend the lower grade bauxites with the Jamaica-1 bauxite to maintain a consistent bauxite feed, however this investigation presents a case study in processing the worst-case type of bauxite blends.

This experiment investigated three major parameters characterizing some of the poorest grade bauxite available: % reactive silica, % aluminous goethite and % boehmite content. Four blends of increasing concentrations were created for each. Albeit the aim was to keep the remaining parameters constant, variation was experienced, especially in the available alumina and phosphate content, which impacted the results. For the purposes of this paper, available alumina will refer to alumina species that are soluble below 150 °C. The % goethite refers to the mass ratio of goethite content compared to the measurable iron content of the bauxite, and similarly the % aluminous goethite refers to the ratio of aluminous goethite compared to the iron content of the bauxite. The chemical composition of the bauxite blends used is shown in Table 1 below.

2. Experimental Method

Each custom bauxite blend was digested with clean spent liquor (CSL), the amount of bauxite calculated to achieve 0.735 blow-off A/C ratio, and the amount of lime needed for phosphorous control (79 – 97 % Calcia). The slurry was digested in a Parr reactor in the laboratory for 35 minutes at 150 °C. The digested slurry was split into eight 1000 mL cylinders and thickener overflow liquor at about 96 °C was added as dilution, up to the 1 L mark to target a solids content of 60 kg/m^3 in each measuring cylinder. A solids test was done on a sample of the blow off slurry to calculate the volume of slurry needed (average 0.35 L) and the volume of dilution liquor needed (average 0.65 L) to achieve the 60 kg/m^3 target. The diluted slurry was reheated to average 92 °C and settling tests performed using 0.1 % solution of modified hydroxamate flocculant. Settling rates were measured by timing the fall of the interface between the 0.9 L and 0.7 L cylinder marks. Supernatant clarity was measured with a Turbidimeter in NTU. Residue compaction was assessed by measuring the height of solids in the base of the cylinder after waiting 30 minutes and was expressed in L. A solids test was done on two of the eight cylinders after completion to determine the average solids content.

Table 1. Chemical composition of bauxite blends used.

Experimental Blends	Total Al_2O_3 (%)	Available Al_2O_3 (%)	Boehmite (%)	SiO_2 (%)	$RSiO_2$ (%)	Fe_2O_3 (%)	P_2O_5 (%)	TiO_2 (%)	Goethite Ratio ($\frac{G}{H+G}$)	Al. Goethite Ratio ($\frac{Al\ G}{H+G}$)
Reactive Silica Blend 1	48.7	42.0	0.48	3.6	2.2	19.0	0.22	2.6	0.40	0.32
Reactive Silica Blend 2	46.4	37.6	0.73	6.0	4.4	18.1	0.39	2.3	0.40	0.32
Reactive Silica Blend 3	44.1	34.7	1.97	9.2	6.6	17.4	0.32	2.2	0.48	0.38
Reactive Silica Blend 4	42.3	19.9	2.22	12.4	7.1	17.3	0.25	2.2	0.48	0.39
Aluminous Goethite Blend 1	48.6	43.1	0.34	2.2	1.3	20.6	0.17	2.6	0.35	0.28
Aluminous Goethite Blend 2	48.6	42.2	0.71	3.3	2.1	18.8	0.82	2.7	0.48	0.38
Aluminous Goethite Blend 3	47.0	39.5	0.80	2.9	1.9	18.1	1.94	2.7	0.66	0.53
Aluminous Goethite Blend 4	46.3	37.9	0.99	1.8	1.2	18.5	3.10	2.7	0.79	0.64
Boehmite Blend 1	48.2	42.1	0.96	2.9	2.6	17.4	0.18	2.5	0.34	0.27
Boehmite Blend 2	48.1	39.9	2.25	4.0	3.8	17.9	0.21	2.4	0.38	0.30
Boehmite Blend 3	48.1	38.5	3.95	4.5	4.2	17.4	0.19	2.4	0.36	0.29
Boehmite Blend 4	48.3	36.7	5.57	5.0	4.3	16.7	0.16	2.4	0.36	0.29

3. Summary of Findings

3.1 Reactive Silica

Increases in the % reactive silica has been known to impact bauxite processability in the following ways: increased formation of Desilication Product (DSP) through reaction with caustic soda, increased scaling on heat exchange surfaces, decreased settling rates, decreased overflow clarity, decreased mud compaction, and increased required flocculant dosages. The increased formation of DSP increases the mud load, and additionally, most of the liquor silica content also recrystallizes out of the circuit with the red mud also increasing the mud load.

The increase in the mud load observed in the investigations are shown in Table 2 below. As the % reactive silica increased, the blow-off solids, which was used as a measure of the mud load generated, also increased. The increase was as high as four times the normal mud load for the high reactive silica blend (7 %) and dilution up to 85 % was needed to achieve the target solids in the thickener simulation. It is worth mentioning that the sharp decrease in % available alumina in the blends also contributed to the increase in the mud load generated.

4. Conclusion

Alumina refineries will require modifications of hardware and operating methods if they are to process the lower grades of bauxite available in Jamaica. These modifications include utilizing high-rate vessels for thickeners/settlers and washers, to accommodate the increased volume from the higher mud load generated, as well as the increased dilution necessary to achieve lower solids. Eductor technology should also be utilized in the feed well to the vessels to facilitate higher dilution (up to 3–4 times) as necessary to process the mud residue. A viscosity or rheology modifier should be used to help process the slurries which will allow for increased solids content, increased pumping capabilities and reduced torque on the rake blades.

5. Acknowledgments

The author would like to thank the Jamalco team, especially the Laboratory, Technical and RD&T departments, for their support in the completion of this experiment and the preparation of this paper. Acknowledgement is also being given to the flocculant supplier whose flocculant was utilized in this experimental work.

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