IMPROVING CHARACTERIZATION OF LOW GRADE DIASPORIC BAUXITE TO BE UTILIZE IN JAJARM ALUMINA PLANT

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Abstract

To increase the proportion of lower grade bauxite in the utilized feed and also possibility of increasing A/S ratio in the plant feed (4.66), some investigations on improving A/S ratio of Elburz Bauxite, especially lower grade ones, by gravitational method and flotation has been carried out. To evaluate heavy media separation, using heavy liquids with different specific gravities between 2.8-3.4 (g/cm3) on various size fractions of this bauxite with initial A/S ratio between 1.3-8.5, resulted that a special specific gravity can produce the concentrates (in sunk fractions) with the A/S ratios and productivities which can economically be used as plant feed . Pilot plant tests also carried out on a 25t sample of Bauxite with a A/S ratio of 2.0 and concentrate A/S and recovery in DMS tests were 3.30 and >40%, respectively.

Introduction

Jajarm Alumina plant has been designed to produce Alumina based on the Chamosite-Diasporic domestic Bauxite by Bayer method [1].

Due to some mistake in its digestion unit design, plant commissioned on March 2002 with Gibbsitic imported Bauxite from India, and after doing remedy actions, on May 2003, has been switched to domestic bauxite as the plant feed.

Based on the quality, quantity and mineralogical characteristics of Elburz Bauxite, and also economical consideration, all parties agreed to feed plant with a Bauxite A/S ratio around 4.4-4.7 coming from nearby mine.

Now, after 8-9 years exploring and exploiting Jajarm mine by open-pit method, not only a large amount of low-grade, Kaolinite and Shale Bauxite has been piled in the mine but also scare up Bauxite with an A/S ratio in the agreed range become very difficult.

So very intensive investigations have been started from 2007 to find processing methods to increase domestic Diasporic Bauxite quality which feeds the plant and also capable to produce a reasonable feed from low-grade, Kaolinite and Shale Bauxite piles.

Theoretical investigation

Long mineralogical study on exploited Bauxite from different part of the Jajarm mine showed that:

1- Among Aluminum bearing minerals, most of the Chamosite:

$$3FeO.3SiO_2.Al_2O_3.\frac{1}{2}MgO.\frac{1}{10}Fe_2O_3.3H_2O)$$

never been digested even at very high temperature, 270°C-275°C which used to digest Diaspore in the plant. By this way, Alumina content of this mineral is non-reactive at the plant condition and discharge to disposal through red mud.

2- Also Silica content of Chamosite is non-reactive at the plant condition and does not go to the liquid phase to produce Hydroaluminosilicates like:

$$Na_2O.Al_2O_3.2SiO_2.2H_2O$$

Thus this type of Silica cannot have a negative effect on the plant economy due to fresh caustic consumption.

3- The typical mineralogy of both feed and low grade bauxite of Jajarm is shown in the Table 1:

Table 1. Weight percent of main minerals in the typical plant feed/low-grade Jajarm Bauxite

Mineral	Chemical Formula	Wt.% @ Feed	Wt.% @ Low-grade
Diaspore	$Al_2O_3.H_2O$	47.05	32.4
Hematite	Fe_2O_3	16.55	14
Chamosite	$3FeO.3SiO_2.Al_2O_3.\frac{1}{2}MgO.\frac{1}{10}Fe_2O_3.3H_2O$	11.67	11.6
Kaolinite	$2SiO_2.Al_2O_3.2H_2O$	8.95	13.8
Anatase	TiO_2	5.01	3.7
Illite	$SiO_2.\frac{3}{16}Al_2O_3.\frac{2}{23}MgO.\frac{1}{7}K_2O.\frac{1}{35}FeO.\frac{3}{4}H_2O$	3.49	4.5
Goethite	$Fe_2O_3.H_2O$	1.49	3.9
Quartz	SiO_2	1.24	6
Calcite	$CaCO_3$	1.19	2.3
cancrinite	$2SiO_2.Al_2O_3.Na_2O.\frac{2}{3}CaCO_3$	1.0	2.4
Boehmite	$Al_2O_3.H_2O$	1.0	1.9
Rutile	TiO_2	0.66	0.63
Gibbsite	$Al_2O_3.3H_2O$	0.61	0.8
Crandallite	$1.5Al_2O_3.P_2O_5.CaO.\frac{7}{2}H_2O$	0.3	0.2
Dolomite	$CaCO_3.MgCO_3$	0.24	0.1
Maghemite	Fe_2O_3	<0.1	<0.1
Pyrite	FeS_2	<0.1	<0.1
Magnetite	$FeO.Fe_2O_3$	0	<0.1

Rearranging table 1 based on minerals density, led to table 2.
A close look at the data of these tables leads that both feed and low-grade Bauxite are composed of 3 parts: high density Segment (covering Iron and Titanium bearing minerals), medium density Segment (mostly included Aluminum bearing minerals) and finally low density Segment (minerals composed of Ca, Mg, Si). Table 3 shows the calculation results based on this segmentation.

Table 2. Densities of main minerals in the feed/low-grade Jajarm Bauxite

Mineral	Chemical Formula	Typical density ($\frac{g}{cm^3}$)
Cancrinite	$2SiO_2.Al_2O_3.Na_2O.\frac{2}{3}CaCO_3$	2.43
Gibbsite	$Al_2O_3.3H_2O$	2.44
Kaolinite	$2SiO_2.Al_2O_3.2H_2O$	2.62
Quartz	SiO_2	2.65
Calcite	$CaCO_3$	2.71
Illite	$SiO_2.\frac{3}{16}Al_2O_3.\frac{2}{23}MgO.\frac{1}{7}K_2O.\frac{1}{35}FeO.\frac{3}{4}H_2O$	2.75
Dolomite	$CaCO_3.MgCO_3$	2.84
Crandallite	$1.5Al_2O_3.P_2O_5.CaO.\frac{7}{2}H_2O$	3.00
Boehmite	$Al_2O_3.H_2O$	3.07
Chamosite	$3FeO.3SiO_2.Al_2O_3.\frac{1}{2}MgO.\frac{1}{10}Fe_2O_3.3H_2O$	3.13
Diaspore	$Al_2O_3.H_2O$	3.38
Anatase	TiO_2	3.88
Rutile	TiO_2	4.25
Goethite	$Fe_2O_3.H_2O$	4.27
Pyrite	FeS_2	5.01
Magnetite	$FeO.Fe_2O_3$	5.21
Hematite	Fe_2O_3	5.28
Maghemite	Fe_2O_3	5.49

Table 3. Segmentation of main minerals in the feed/low-grade Jajarm Bauxite based on density

Segment	Weight Average Density		Weight Percent	
	Feed Bauxite	Low-grade Bauxite	Feed Bauxite	Low-grade Bauxite
Low Density	2.64	2.63	16.6	30.4
Medium Density	3.32	3.30	59.8	46.9
High Density	4.89	4.84	23.6	22.6

Non reacting Chamosite (indeed non-reactive Silica) lies in the middle segment and mostly all reactive Silica lies in the first segment. It means that if by any means, we are able to separate low density part of domestic Bauxite, we have the opportunity to remove major part of reactive Silica from the plant feed before consumption and this means great saving in the consumption of fresh Caustic without any further Red mud Causticization step.
Also by this means low-grade Bauxite can be upgraded and available to be used as the plant feed.

3-Materials and methods

As for the theoretical conclusions, investigate the possibility of using physical separation methods for processing domestic Diasporic Bauxite was schedule.
Several studies on different separation method like: controlled crushing and selective grinding , Hydrocyclone classification, Reverse Flotation, Jig, Shaking table and Heavy media separation conducted in the lab scale [2][4][5][6].
Insomuch the results of Jajarm Bauxite mining accumulate in 8 piles as the consumable Bauxite and 3 piles as the non-consumable ones (as shown in table 4), the primary investigations on Heavy media method was done on heap 2 and the result have already been published [3].

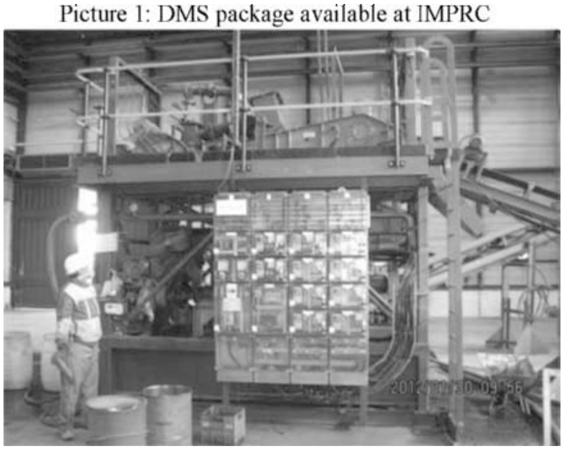
Table 4. Heaps resulted of Jajarm bauxite mining

Name	Al_2O_3 wt.% (typical)	SiO_2 wt.% (typical)	A/S ratio (typical)
Consumable			
Heap 1	39-41	14-18	2.2-2.9
Heap 2	43-45	12.5-15	2.9-3.6
Heap 3	46-47.5	11-13	3.6-4.3
Heap 4	47.5-52	9.5-11	4.3-5.5
Heap 5	52-54	8-9.5	5.5-6.7
Heap 6	55-57	6-8.5	6.7-7.9
Heap 7	57-60	5.5-7	7.9-11
Heap 8	>60	<5.5	>11
Non-Consumable			
Hard Low-grade	39-41	19-23	1.8-2.2
Kaolinitic	39-41	23-28	1.4-1.8
Shally	32-35	26-28	1.2-1.4

By all these tests, surprisingly, it was found that heavy media processing method had a very positive effect to separate low density segment of domestic Diasporic bauxite and economically increased its A/S ratio with a reasonable recovery and decreased its fresh Caustic consumption during Digestion step [7].
The other methods had not considerable effect on separation of minerals and increasing A/S ratio which also theoretically was predictable. For example, crystallography studies had shown that there is a similarity and proximity between physical-chemical properties of the low density segment's crystal surface caused by grinding of Elburz Bauxite (especially Aluminosilicates) and the crystal surface of other segments [3]. So this was expected that separation method based on difference of surface properties of crystals, like reverse Flotation, was not effective on Elburz Bauxite and lab tests confirmed this [4].
Also on the basis of the textural investigation, it could be declared that this Bauxite cannot be reasonably enriched neither by means of selective grinding and classification nor by magnetic separation [1] and laboratory and field tests also supported this opinion [2][5][8].

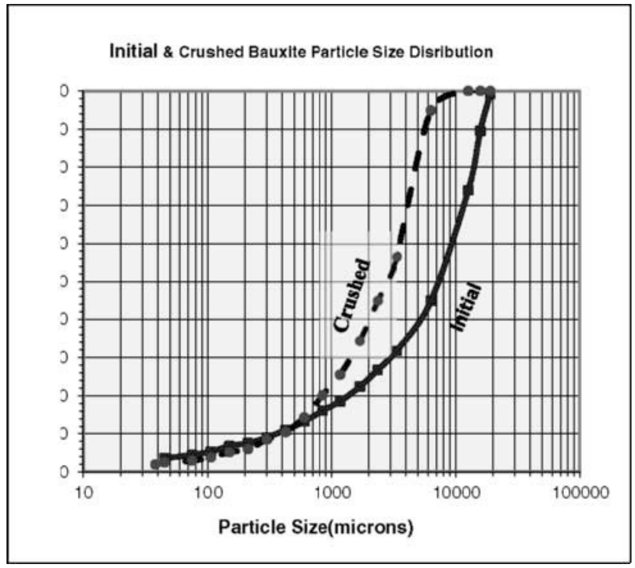
Other Gravitational separation methods like Jig and Shaking table were not as effective as heavy media method because of pleomorphic micro granular texture of domestic Bauxite with several secondary textural elements in it [1][2].
With these findings, it was found that the best result for enriching domestic Diasporic Bauxite can be gained using heavy media separation method. So, a series of intensive Sink-float analysis study started on all heaps of Jajarm mine (expect heap 2 which has been studied before [3]), including consumable and also non-consumable piles [6].
Sampling and preparation was as the same as previous work [3]. However, the largest particle size was in the range of 6730 microns and three sizes of −6730+1190, −1190+500, and −500+125 µm were screened and used for analysis. Also 3 densities of media, 2.9, 3.1, 3.3, were selected to run separation tests. The results of these Sink-float tests with a media density around 3.1 have been shown on tables 5 to 7.
Due to the excellent result of laboratory tests and accumulation of a considerable amount of non-consumable Bauxite in the mine, 25 tons of hard low-grade Bauxite for extensive pilot studies was carried to Iran Mineral Processing Research Center (IMPRC).
There was a $5\frac{t}{h}$ Bateman DMS pilot package, which all tests carried out on it (Picture 1).

Picture 1: DMS package available at IMPRC

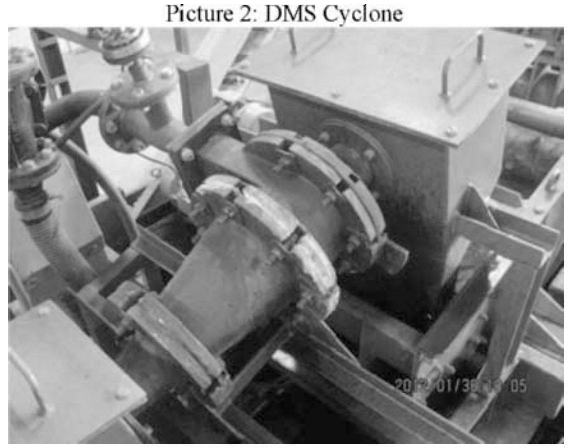


Because the particle size of the carried Bauxite was as the same as what feeds to the Jajarm plant ball mills(means -20mm), before starting pilot testing a crushing stage was done to decrease the size of feed Bauxite to -7mm. Chart 1 show the screen analysis of the initial and crushed Bauxite.
Using water - special grade Ferrosilicon slurry as the dense media and a feed rate adjusted around 1 - $1.5\frac{t}{h}$, required tests were done within a media density range of 2.2 -2.9 $\frac{g}{cm^3}$.
According to the design of the DMS pilot package, it was equipped with a wet wedge screen to remove under 1.16 mm particles of the feed to avoid its negative effect on heavy media influence.
Main separation was carried out in a cyclone slightly inclined to the horizon (10°- 15° Slope) (Picture 2). Before the cyclone, It is equipped a Densifier to create required density of media entering cyclone (Picture3).
After automatic adjustment of required media density and reaching stable state, Bauxite feeding to the package was started within desired rate range.

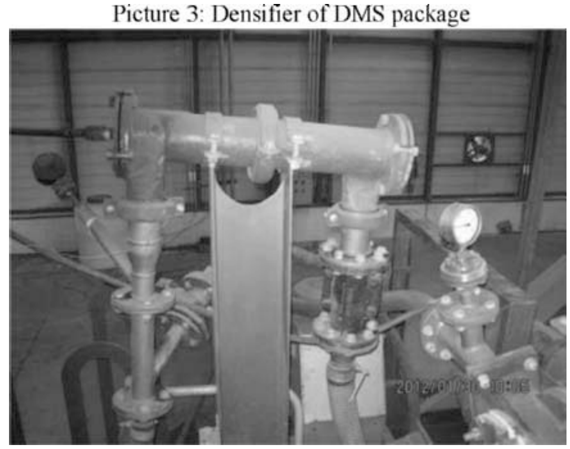
Chart 1: Screen analysis of the initial & crushed Bauxite carried to IMPRC



Picture 2: DMS Cyclone



Picture 3: Densifier of DMS package



At the DMS cyclone outlets, both underflow and overflow were thoroughly washed under water jet nozzles and accumulated in the respective barrels. Sampling was done in barrels, afterwards.
To investigate behavior of the ore dressed Bauxite during Digestion process in the plant, some Digestion tests at plant

Condition (40min. at 270℃ plus 8-10% Lime) did in the laboratory Digestion autoclave (table 14)[8].

Results and discussion

Based on the laboratory Sink-float tests on all kind of Jajarm Bauxite (tables 5-7) , we concluded that this method is effective on any kind of this bauxite at a size less than 7 mm with acceptable recovery as was previously claimed about Heap 2 [3].

Table 5. Chemical analysis of different pile samples in the size range feed to Sink-float tests

Name	Size range(μ)	Wt.% of total	Wt.% Al_2O_3	Wt.% SiO_2	A/S
Hard Low-grade *	-6730 +1190	59	43.52	14.03	3.1
	-1190 +500	18.2	44.03	13.53	3.25
	-500 +125	14.5	43.04	14.46	2.98
Kaolinitic	-6730 +1190	73.4	36.15	29.46	1.23
	-1190 +500	13.8	37.58	27.3	1.38
	-500 +125	8.5	38.45	25.44	1.51
Shally	-6730 +1190	73.1	34.79	27	1.29
	-1190 +500	15	33.89	24.21	1.4
	-500 +125	8	34.72	26.04	1.33
Heap 1	-6730 +1190	66.5	40.14	16.59	2.42
	-1190 +500	15.2	39.55	17.66	2.24
	-500 +125	11.4	40.33	16.61	2.43
Heap 3	-6730 +1190	71.3	43.77	1312	3.34
	-1190 +500	12.8	43.37	13.38	3.24
	-500 +125	9.5	42.4	14.48	2.93
Heap 4	-6730 +1190	67.8	48.08	10.94	4.39
	-1190 +500	15.6	47.64	10.61	4.49
	-500 +125	10.9	47.66	10.39	4.59
Heap 5	-6730 +1190	71.3	53.04	7.23	7.34
	-1190 +500	15.2	52.58	7.67	6.86
	-500 +125	9.1	52.25	7.68	6.67
Heap 6-8	-6730 +1190	65.8	56.75	6.68	8.5
	-1190 +500	16.7	55.81	6.97	8.01
	-500 +125	11.8	55.78	6.89	8.1

* Main Sample has been already crushed and mixed by a higher grade Bauxite by mistake

Chemical analysis of the Bauxite carried to and crushed in IMPRC pilot, were shown in table 8. Densities of these Bauxite was around 3.10 –3.11 $\frac{g}{cm^3}$. Tables 9&10 show the results of the selected DMS pilot tests did in IMPRC on this Bauxite.

Table 6. Chemical analysis and Wt. % of Sink phases of Sink-float experiments with media density = 3.1

Name	Size range(μ)	Wt.% of Sink	Wt.% Al_2O_3 **	Wt.% SiO_2 **	A/S
Hard Low-grade *	-6730 +1190	43.23	45.53	7.79	5.84
	-1190 +500	39.97	47.30	7.53	6.28
	-500 +125	46.86	46.12	8.01	5.76
Kaolinitic	-6730 +1190	19.58	41.40	10.97	3.78
	-1190 +500	23.47	47.45	12.11	3.92
	-500 +125	33.4	48.44	11.67	4.15
Shally	-6730 +1190	17.03	37.17	16.16	2.30
	-1190 +500	19.02	40.29	14.24	2.83
	-500 +125	21.13	36.72	14.18	2.59
Heap 1	-6730 +1190	46.81	45.56	8.37	5.44
	-1190 +500	55.77	42.96	9.85	4.36
	-500 +125	47.60	46.75	9.82	4.76
Heap 3	-6730 +1190	73.13	41.23	8.98	4.59
	-1190 +500	70.59	46.20	8.64	5.35
	-500 +125	72.03	41.66	9.28	4.49
Heap 4	-6730 +1190	87	46.22	8.52	5.42
	-1190 +500	87.14	43.93	7.83	5.61
	-500 +125	86.25	48.83	8.40	5.82
Heap 5	-6730 +1190	95.61	54.24	6.87	7.90
	-1190 +500	94.98	52.83	6.89	7.67
	-500 +125	95.12	51.25	6.74	7.60
Heap 6-8	-6730 +1190	94.51	61.90	6.54	9.46
	-1190 +500	94.48	57.04	6.37	8.95
	-500 +125	92.21	56.73	6.13	9.25

* Main Sample has been already crushed and mixed by a higher grade Bauxite by mistake - ** Corrected based on the Sink mass

As one of the most fundamental difference between laboratory static and DMS pilot dynamic tests, should include media density effect on separation.This difference is due to the fact that in laboratory methods, the only force resulted separation is Buoyancy whereas at industrial equipment like DMS cyclone, there are Centrifugal; Drag and Diffusive force that effect separation in addition to Buoyancy. So in industry, it is possible to do the same separations at media densities lower than what used in lab tests. Comparing tables 6&7 with tables 9&10&12, led to the discovery of this fact for processing Jajarm Bauxite too. It can be seen that using media density 2.25-2.3 $\frac{g}{cm^3}$ at DMS cyclone (almost less than the density of all minerals exist at feed Bauxite!) led to the same results were obtained using media density 3.0-3.1 $\frac{g}{cm^3}$ at laboratory tests.

Table 7. Chemical analysis and Wt. % of float phases of Sink-float experiments with media density = 3.1

Name	Size range(μ)	Wt.% of Sink	Wt.% Al_2O_3**	Wt.% SiO_2**	A/S
Hard Low-grade *	-6730 +1190	56.77	39.40	17.78	2.22
	-1190 +500	60.03	41.26	17.33	2.38
	-500 +125	53.14	38.98	19.60	1.99
Kaolinitic	-6730 +1190	80.42	35.25	34.02	1.04
	-1190 +500	76.53	35.39	32.38	1.09
	-500 +125	66.6	35.48	33.64	1.05
Shally	-6730 +1190	82.97	33.90	28.92	1.17
	-1190 +500	80.98	35.25	28.51	1.24
	-500 +125	78.87	34.99	29.67	1.18
Heap 1	-6730 +1190	53.19	37.22	24.51	1.52
	-1190 +500	44.23	34.35	26.82	1.28
	-500 +125	52.4	37.35	23.95	1.56
Heap 3	-6730 +1190	26.87	36.77	19.56	1.88
	-1190 +500	29.41	36.40	24.57	1.48
	-500 +125	27.97	35.27	24.13	1.46
Heap 4	-6730 +1190	13	39.71	22.11	1.80
	-1190 +500	12.86	39.53	21.76	1.82
	-500 +125	13.75	41.14	23.07	1.78
Heap 5	-6730 +1190	4.39	51.81	18.49	2.80
	-1190 +500	5.2	46.40	21.38	2.17
	-500 +125	4.88	42.53	21.24	2.00
Heap 6-8	-6730 +1190	5.49	51.02	18.66	2.73
	-1190 +500	5.52	47.77	18.74	2.55
	-500 +125	7.79	49.05	16.42	2.99

* Main Sample has been already crushed and mixed by a higher grade Bauxite by mistake - ** Corrected based on the Float mass

Table 8. Chemical analysis of the Bauxite carried to and crushed in IMPRC

Name	Size range(μ)	Wt.%	Wt.% Al_2O_3	Wt.% SiO_2	A/S
Carried Initial	-20000	100	38.10	19.45	1.96
Secondary Crushed	-6730	100	38.75**	19.44**	1.99
	-6730 +1190*	75	38.83	19.03	2.04
	-1190	25	38.49	20.66	1.86

* Actual feed to DMS Cyclone - ** Calcullated

Table 9. Chemical analysis of DMS cyclone overflow resulted by using different media density (float phase)

Media Density	Wt.%	Density ($\frac{g}{cm^3}$)	Wt.% Al_2O_3	Wt.% SiO_2	A/S
2.2	37.6	2.94	37.04	24.75	1.50
2.25	55.2	2.95	37.85	23.13	1.64
2.30	72.8	3.05	39.03	21.11	1.85
2.35	79.9	3.01	38.89	20.18	1.93
2.40	81.5	3.04	38.00	22.60	1.68
2.45	80.3	3.05	39.11	20.48	1.91

Table 10. Chemical analysis of DMS cyclone underflow resulted by using different media density (Sink phase)

Media Density	Wt.%	Density ($\frac{g}{cm^3}$)	Wt.% Al_2O_3	Wt.% SiO_2	A/S
2.2	62.4	3.32	38.44	14.80	2.60
2.25	44.8	3.34	40.12	13.17	3.05
2.30	27.2	3.34	39.64	12.67	3.13
2.35	20.1	3.40	38.19	11.95	3.20
2.40	18.5	3.40	38.06	11.58	3.29
2.45	19.7	3.48	38.00	11.66	3.26

The other observations in pilot tests were that the average humidity of Bauxite increases from 0.5% at the package entrance to about 5% at DMS cyclone's outlets and densities of the overflow were 2.9-3.1 $\frac{g}{cm^3}$ (lower than feed) and of the underflow were 3.3-3.5 $\frac{g}{cm^3}$ (higher than feed) .

Also increasing media density from 2.2 to 2.45, resulted to an increase in underflow's $\frac{A}{S}$ from 2.60 to 3.30 while overflow's $\frac{A}{S}$ also increased nearly 0.3 units. But Recovery (Wt.% of underflow related to feed) had a reverse behavior with media density enhancement (as expected theoretically).

Based on the laboratory Sink-float tests on non-consumable Bauxite, we expected a lower minimum $\frac{A}{S}$ on the overflow of DMS cyclone (expected 1.3-1.4). It seemed that the size of the IMPRC package's cyclone, specially its bottom Spigot, was not suitable for our separation. So we transfer a random mix of tests overflows again as the feed of the cyclone in a subsequent test (keeping media density 2.25). The results are in the table 11. Surprisingly nearly 35% of these primary overflows again separated as the underflow of secondary cyclone with a $\frac{A}{S}$ ratio around 3.10 while the overflow's was 1.50. So it is evident that using proper size cyclone or subsequent cyclones can lead to a deeper separation and increase Recovery of desired Bauxite.

Another strange outcome of the DMS tests resulted when we increased media density above 2.50 (tables 12&13) [7].

In this range of media density, a sharp increase in the underflow density occurred while its $\frac{A}{S}$ ratio decreased surprisingly, instead of increasing. This is because a separation between high density and medium density segment at these media density range (instead of a low density brush off the two other segments which occurred at lower media densities). Iron content of the underflows was well documented this finding.

With respect to all results, media density of 2.25-2.30 $\frac{g}{cm^3}$ is the best not only from the point of view of resulted underflow $\frac{A}{S}$ but also at least it's recovery is near 60% (nearly 40% by primary cyclone and the other 20% by the secondary cyclone, related to feed).

Table 11. Chemical analysis of secondary DMS cyclone outlets fed by a selected primary overflow

Bauxite	Wt. %	d ($\frac{g}{cm^3}$)	Wt.% Al_2O_3	Wt.% SiO_2	A/S
Feed	100	2.98	39.56	20.95	1.89
Overflow	65.1	2.93	37.06	24.41	1.52
Underflow	34.9	3.24	42.78	13.85	3.09

Table 12. Chemical analysis of DMS cyclone overflow resulted by using media density above 2.50

Media Density	Density ($\frac{g}{cm^3}$)	Wt.% Al_2O_3	Wt.% SiO_2	Wt.% Fe_2O_3	A/S
2.50	3.08	40.16	20.48	19.53	1.96
2.55	3.08	39.24	19.84	20.44	1.98
2.70	3.11	41.79	19.33	21.12	2.16
2.80	3.07	40.95	19.28	21.85	2.12
2.90	3.12	40.16	18.31	23.75	2.19

Table 13. Chemical analysis of DMS cyclone underflow resulted by using media density above 2.50

Media Density	Density ($\frac{g}{cm^3}$)	Wt.% Al_2O_3	Wt.% SiO_2	Wt.% Fe_2O_3	A/S
2.50	3.53	38.60	12.38	34.61	3.12
2.55	3.55	35.27	11.50	38.32	3.07
2.70	3.79	25.81	9.77	52.99	2.64
2.80	3.89	23.68	9.29	56.47	2.55
2.90	3.96	21.12	8.85	61.15	2.39

The most interesting results of this project, when obtained that we did Digestion tests on ore dressed Bauxite and compare it with raw/sieved low-grade Bauxite and also annual results of the Jajarm Alumina plant operation.

As tables 14& 15 shows, there was a more than 50% increase in the Digestion efficiency and 200% decrease in Fresh Caustic consumption when low-grade Bauxite exposed to ore dressing process. Also comparing these results with the annual Jajarm Alumina plant operation, we cannot find any dramatic difference between them. It means that ore dressed low-grade Bauxite not only can be used directly as the plant feed without any further trouble but also there will be some benefits in the processing of all domestic Diasporic Bauxite before transfer to plant like:

(1) Removing a major amount of minerals with reactive Silica from plant feed, which is equal to reduce fresh Caustic consumption without any further Causticization step.

(2) Using ore dressed Bauxite as feed and eliminating Causticization step by Lime, can reduce Lime production and usage at Jajarm Alumina plant to half.

(3) 5% humidity of processed Bauxite can reduce notable problems of dry Jajarm Bauxite due to Bauxite dust during carrying, storage, homogenization, handling and transport to ball mill, in a tangible way.

(4) Due to the higher density of ore dressed Bauxite and demand of less Lime during Digestion and Causticization step, Red muds of the ore dressed Bauxite are more dense than the muds of the non-processed Jajarm Bauxite, and will show a good settling behavior in the mud washers.

(5) By this method, large amount of the mined Jajarm Bauxite which due to the high reactive Silica are useless now, can be processed and consume directly as the plant feed . Also desire for exploration and mining of lower grade Bauxite will increase at the Jajarm mine.

(6) Some domestic Bauxite resources which are far from Jajarm and due to this distance away are non-economic to be mined and carried Jajarm, can be ore dressed in place and then higher grade Bauxite will be economical to carry Jajarm and used at Alumina plant.

Table 14. Results of Digestion test conducted on selected raw/sieved/ore dressed Bauxite.

Bauxite	Before Digestion		After Digestion			
	Wt.% Al_2O_3	Wt.% SiO_2	Wt.% Al_2O_3	Wt.% SiO_2	Wt.% Na_2O	Liq. α_c
A	47.41	12.44	18.58	15.53	6.78	1.46
B	39.64	12.67	16.63	13.82	4.68	1.51
C	41.34	17.57	19.31	18.74	7.63	1.55
D	40.16	18.31	19.58	19.41	8.60	1.56

* A=Plant feed B=Pilot ore dressed (d=2.3) C=Sieved low-grade D=Raw low-grade

Table 15. Calculated Specific consumpt./prod. based on Digestion test conducted on selected raw/sieved/ore dressed Bauxite

Bauxite	*Digestion Efficiency (%)	Bauxite (Tone)	Fresh Caustic (Tone)	Red Mud (Tone)
Plant feed	68.4	3.05	0.24**	2.55
Pilot ore dressed (d=2.3)	65	3.86	0.26	3.29
Sieved low-grade	55.2	4.38	0.53	4.01
Raw Low- grade	42.5	5.86	0.87	5.92

*8% lime - ** With Secondary Causticization and Carbonate Recovery

Conclusions

Both Sink-float laboratory and DMS pilot test demonstrated that heavy media treatments performed on a variety of Jajarm Bauxite was effective and had reasonable results related to other ore dressing methods. Techno-Economic feasibly study for establishing a 60 t/h industrial plant at Jajarm mine was carried out with IRR and NPV equal: 39.98 and 1,989,752$, respectively, as the result. Taking k Coefficient as 0 and 20, the return on investment of this project is 4 and 5 years, respectively [9].

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