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Improving Characterization of Low Grade Elburz Bauxite to Be Utilized in Jajarm Alumina Plant

Mohammadtaghi Shadloo[1)], Mohammad Zarbayani[2]

[1)] Jajarm Alumina Company, Jajarm, Iran
[2)] General mechanic Company, Babol, Iran

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Abstract

To increase the proportion of lower grade bauxite in the utilized feed and also the possibility of increasing A/S ratio (Al_2O_3 to SiO_2 mass ratio) in the plant feed (4.66), some investigations have been carried out on improving A/S ratio of Elburz Bauxite, especially lower grade ones, by gravitational method and flotation. To evaluate heavy media separation, heavy liquids with different specific gravities in the range of 2.8-3.4 (g/cm3) have been used on various size fractions of this bauxite with initial A/S ratio between 1.3-8.5. 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 3.40 and >40%, respectively

Introduction

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

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

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

Now, after 10-11 years exploring and exploiting the Jajarm mine by open-pit method, not only has a large amount of low-grade, kaolinite and shale Bauxite stockpiled in the mine but also there is a scarcity of Bauxite with an A/S ratio in the agreed range.

Therefore, very intensive investigations have started from 2007 to find processing methods to increase the quality of feeds to the plant that are capable of producing a reasonable feed from low-grade, kaolinite and Shale Bauxite stockpiles.

Theoretical investigation

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

1- Among Aluminium bearing minerals, most of the Chamosite, (typically: $3FeO.3SiO_2.Al_2O_3.{}^1/_2 MgO.{}^1/_{10} Fe_2O_3.3H_2O$) never digests even at very high temperatures 270℃-275℃ that used to digest Diaspore in the plant. Thus, Alumina content of this mineral is non-reactive under the plant conditions and it is discharged to disposal through red mud.

2- The silica content of Chamosite is also non-reactive under 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 economics due to caustic soda consumption.

3- The typical mineralogy of both the feed and low-grade bauxite of Jajarm is shown in the Table 1. If we rearrange Table 1 based on minerals density, we get Table 2.

Table 1: Weight precents of main minerals in the feed/low- grade Jajarm Bauxite

Mineral	Chemical Formula	Wt.% @ Feed	Wt.% @ Low-grade
Maghemite	Fe_2O_3	<0.1	<0.1
Hematite	Fe_2O_3	12.3	14
Magnetite	$FeO.Fe_2O_3$	0	<0.1
Pyrite	FeS_2	<0.1	<0.1
Goethite	$Fe_2O_3.H_2O$	3.6	3.9
Rutile	TiO_2	0.9	0.63
Anatase	TiO_2	5.7	3.7
Diaspore	$Al_2O_3.H_2O$	48.3	32.4
Chamosite	$3FeO.3SiO_2.Al_2O_3.{}^1/_2 MgO. {}^1/_{10} Fe_2O_3.3H_2O$	8.8	11.6
Boehmite	$Al_2O_3.H_2O$	1.8	1.9
Crandallite	$1.5Al_2O_3.P_2O_5.CaO. {}^7/_2 H_2O$	0.4	0.2
Dolomite	$CaCO_3. MgCO_3$	0.6	0.1
Illite	$SiO_2. {}^3/_{16} Al_2O_3. {}^2/_{23} MgO. {}^1/_7 K_2O. {}^1/_{35} FeO. {}^3/_4 H_2O$	3.2	4.5
Calcite	$CaCO_3$	0.8	2.3
Quartz	SiO_2	0.04	6
Kaolinite	$2SiO_2.Al_2O_3. 2H_2O$	8.2	13.8
Gibbsite	$Al_2O_3.3H_2O$	0	0.8
Cancrinite	$2SiO_2.Al_2O_3. Na_2O.^2$ ⁄₃ CaCO	5.7	2.4

A close look at the data of these table indicates that both feed and low-grade Bauxite are comprised of three parts: a high-density segment (comprises Iron and Titanium bearing minerals), a medium-density segment (including most of the Aluminium bearing minerals) and finally a low-density segment (comprises of minerals bearing Ca, Mg, Si). Table 3 shows the related segmentation results.

Non-reacting Chamosite (indeed non-reactive Silica) lies in the middle segment and almost all reactive Silica lies in the last segment. It means that if by any means, we are able to separate the low-density part of Elburz Bauxite, we have the opportunity to remove a large portion of reactive Silica of the plant feed before consumption and this equates to a big saving in fresh Caustic consumption without any further red mud Causticization. Also by this means, low-grade Bauxite can be upgraded and is then available to use as the plant feed.

Table 2: densities of main minerals in the feed/low- grade Jajarm Bauxite

Mineral	Chemical Formula	den. ($\frac{g}{cm^3}$)
Maghemite	Fe_2O_3	5.49
Hematite	Fe_2O_3	5.28
Magnetite	$FeO.Fe_2O_3$	5.21
Pyrite	FeS_2	5.01
Goethite	$Fe_2O_3.H_2O$	4.27
Rutile	TiO_2	4.25
Anatase	TiO_2	3.88
Diaspore	$Al_2O_3.H_2O$	3.38
Chamosite	$3FeO.3SiO_2.Al_2O_3.{}^1/_2\ MgO.\ {}^1/_{10}\ Fe_2O_3.3H_2O$	3.13
Boehmite	$Al_2O_3.H_2O$	3.07
Crandallite	$1.5Al_2O_3.P_2O_5.CaO.$ ${}^7/_2$ H	3.00
dolomite	$CaCO_3.\ MgCO_3$	2.84
Illite	$SiO_2.\ {}^3/_{16}\ Al_2O_3.\ {}^2/_{23}\ MgO.\ {}^1/_7\ K_2O.\ {}^1/_{35}FeO.\ {}^3/_4H_2O$	2.75
Calcite	$CaCO_3$	2.71
Quartz	SiO_2	2.65
Kaolinite	$2SiO_2.Al_2O_3.\ 2H_2O$	2.62
Gibbsite	$Al_2O_3.3H_2O$	2.44
cancrinite	$2SiO_2.Al_2O_3.\ Na_2O.{}^2/_3$ CaCO	2.43

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

Segment	Weight Average Density		Weight Precent	
	Feed	Low-grade	Feed	Low-grade
high density	4.72	4.84	23	24
medium density	3.33	3.30	60	46
Low density	2.59	2.63	17	30

Materials and methods

Following these theoretical conclusions, the potential of using physical separation methods was investigated.

Several investigations on different Separation method such as controlled crushing and selective grinding , Hydrocyclone classification, reverse flotation, Jig, shaking table and heavy media separation were conducted in the lab scale [2][4][5][6].

Insomuch that mining extraction of Jajarm Bauxite accumulate in 8 stockpiles as the consumable Bauxite and 3 stockpiles as the non-consumable ores (as shown in table 4), the first investigations on heavy media method was done on heap 2 and the result have already internationally published [3].

Surprisingly, it founded that heavy media processing method has a very positive effect in separating the low-density segment of Elburz bauxite and economically increases its A/S ratio with a reasonable recovery and decreases its fresh Caustic consumption [7].

The other methods had not significant effect on separation of minerals and increasing A/S ratio that also theoretically was predicted. For example, crystallography studies have shown that there is a similarity and consistency between physical-chemical properties of the low-density segment's crystal surface caused by grinding of Elburz Bauxite, especially Aluminosilicate, and the crystal surface of other segments [3].

Table 4: Heaps resulted of Jajarm bauxite mining stockpiles

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

So it was expected that separation method based on difference of surface properties of crystals, like reverse flotation, would not be effective on Elburz Bauxite and lab tests confirmed this [4].

Also based on the textural investigation, it is observed that either this Bauxite cannot be enriched by selective grinding or by classification or by magnetic separation [1] and the results of laboratory tests also support this opinion [4] [5]. Because of the pleomorphic micro granular texture of Elburz Bauxite with several secondary textural elements in it, other Gravitational separation methods like Jig and shaking table, was not as effective as heavy media separation method [4][6].

With these qualities, it is founded that the best result for enriching Elburz Bauxite can be attained using the heavy media separation method. Therefore, a series of intensive sink-float analysis study started on all heaps of the Jajarm mine (except heap 2 which has been studied before [3]), including consumable and non-consumable stockpiles [6]. Sampling and preparation was the same as in previous work [3]. However, the largest particle size was in the range of 6730 microns and 3 spans of −6730+1190, −1190+500, and −500+125 μm were screened and used for analysis. In addition, three densities of media, 2.9, 3.1, 3.3, were selected to run in separation tests. The results of these sink-float tests with a media density around 3.1 are shown on Tables 5 to7.

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 studies carried to Iranian Mineral Processing Research Centre (IMPRC). There was a 5 $\frac{t}{h}$ Bateman DMS pilot package [Picture 1], where all tests were carried out.

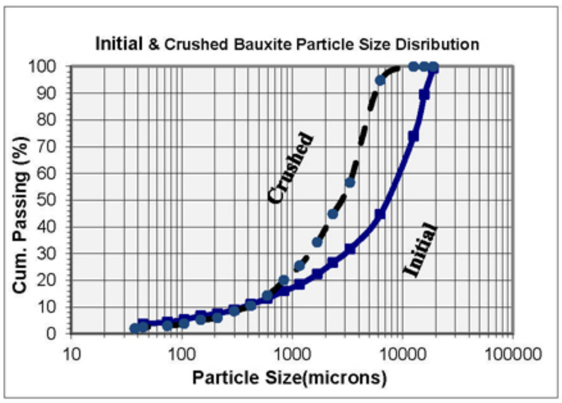
Because the particle size of the Bauxite was as same as the feeds to the Jajarm plant ball mills (means -20mm) , before starting pilot testing, a crushing stage to decrease the size of the feed Bauxite to -7mm, was done. Chart 1 shows the screen analysis of the initial and final crushed Bauxite.

Using a water - special grade Ferrosilicon slurry as the dense media and a feed rate adjusted around 1 - 1.5 $\frac{t}{h}$, the 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 in the feed to avoid its negative effect on heavy media separation.

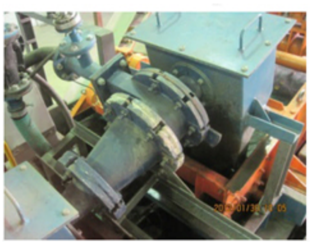
Picture 1: DMS package available at IMPRC

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



Separation was carried out in a cyclone slightly inclined to the horizontal (10°- 15° Slope) [Picture 2].
Before the cyclone, a Densifier is placed to achieve the required density of the media entering the cyclone [Picture3].

Picture 2: DMS cyclone



Picture 3: Densifier of the DMS

After automatic adjustment to the required media density and reaching stable state, feeding of Bauxite to the package started within the desired range.
At the DMS cyclone outlets, both underflow and overflow were thoroughly washed under water jet nozzles and accumulated in the respective barrels. Sampling was then carried out from these barrels.
To investigate characterization of the ore dressed Bauxite during Digestion process in the plant, some Digestion tests at the plant condition (40min retention @ 270℃ adding 8-10% Lime) were carried out in a laboratory Digestion autoclave [Table 14 shows the results].

Results and discussion

Based on the laboratory sink-float tests on all of the Jajarm Bauxite (tables 5-7) , we concluded that this method is effective on all samples of this Bauxite with a size less than 7 mm with an acceptable recovery as was previously claimed for heap 2 [2]. Chemical analysis of the Bauxite fed to and crushed in the IMPRC pilot plant, are showed in Table 8. Densities of these Bauxite was around 3.10 –3.11 $\frac{g}{cm^3}$. In addition, Tables 9&10 show the results of the selected DMS pilot tests done in IMPRC.
As one of the most fundamental difference between laboratory static and DMS pilot dynamic tests, should include media density effect on separation.

Table 5: Chemical analysis of different pile's samples in the size range feed to the sink-float tests

Pile	Size range(μ)	Wt.% of total	Wt.% Al_2O_3	Wt.% SiO_2	A/S ratio
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 with a higher grade Bauxite by mistake

This difference is related to the fact that in laboratory methods, the only force resulting separation is Buoyancy whereas at industrial equipment like the DMS cyclone, there are centrifugal; drag and diffusive forces that effect on the separation in addition to Buoyancy. Therefore, in industry, it is possible to do the same separation at media densities lower than what used in lab tests.
Comparing contents of Tables 6&7 with tables 9&10&12, led to the confirmation of this fact for processing Jajarm Bauxite too. Clearly, It can be seen that using media density 2.25-2.3 $\frac{g}{cm^3}$ at DMS cyclone (almost a density less than the density of all minerals existing in the feed Bauxite!) led to the same results were obtained using media density 3.0-3.1 $\frac{g}{cm^3}$ at laboratory tests.

Table 6: Chemical analysis and Wt. % of sink phases of experiments with media density = 3.1

Stock pile	Size range(μ)	Wt.% of Sink	Wt.% Al_2O_3**	Wt.% SiO_2**	A/S ratio
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 with a higher grade Bauxite by mistake - ** Corrected based on the mass

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

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

Stock pile	Size range(μ)	Wt.% of Sink	Wt.% Al_2O_3**	Wt.% SiO_2**	A/S ratio
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 with a higher grade Bauxite by mistake - ** Corrected based on the mass

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 $\frac{A}{S}$ ratio of overflow also increased nearly 0.3 units. However, Recovery (weight percentage of underflow related to feed) had the reverse behaviour with media density enhancement (as expected theoretically).

Based on the laboratory sink-float tests on the non-consumable Bauxite, we expected a lower $\frac{A}{S}$ Range on the overflow of the DMS cyclone (around 1.3-1.4). It seemed that the size of the IMPRC package's cyclone, specially its Spigot, was not suitable for our separation. Therefore, we transferred the overflow of a selected test (test with media density of 2.25) again as the feed of the cyclone in a subsequent test. The results are in Table 11 (keeping media density 2.25). Surprisingly nearly, 35% of this primary overflow separated as the underflow of the secondary cyclone with a $\frac{A}{S}$ ratio around 3.10 while the overflow ratio was 1.50.

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 ratio
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 - ** Corrected base

Table 9: Chemical analyses of DMS cyclone overflow resulting from using the different media densities

Media Density	Wt. %	Density ($\frac{g}{cm^3}$)	Wt.% Al_2O_3	Wt.% SiO_2	A/S ratio
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 resulting from using the different media densities

Media Density	Wt. %	Density ($\frac{g}{cm^3}$)	Wt.% Al_2O_3	Wt.% SiO_2	A/S ratio
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

Another interesting outcome of the tests resulted when we increased media density above 2.50 [tables 12&13].

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

Media Density	Wt. %	Density ($\frac{g}{cm^3}$)	Wt.% Al_2O_3	Wt.% SiO_2	A/S ratio
Feed (overflow of 1'st cyclone)	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

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. We think this is because a separation between high-density and medium-density segment in these media density range instead of a low-density segment exclusion of the two other segments, which occurred in lower media densities. Iron content of the underflows confirms this fact.

Table 12: Chemical analyses of DMS cyclone overflow resulting from 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 ratio
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 ratio
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

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

The most interesting results of this project were obtained when we did digestion tests on the ore dressed Bauxite and compared it with raw low grade Bauxite and the annual results of the Jajarm plant.

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 the ore dressing process. Also comparing these results with the annual Jajarm Alumina plant operation results, we did not find any dramatic difference between them.

Table 14: Results of Digestion test conducted on selected raw and ore dressed Bauxite.

Bauxite	Before Digestion		After Digestion			
	Wt.% Al_2O_3	Wt.% SiO_2	Wt.% Al_2O_3	Wt.% SiO_2	η (%)	α
Raw Low grade	40.2	18.3	19.58	19.41	42.5	1.56
Lab Ore Dressed (d=3.0)	45.7	11.2	16.52	14.11	71.2	1.46
Pilot ore Dressed (d=2.3)	39.6	12.7	16.63	13.82	64.9	1.51

Table 15: Calculated specific consumption based on the results of Digestion test conducted on selected raw and ore dressed Bauxite (using 8% Lime at Digestion).

Bauxite	Digestion Efficiency (%)	Bauxite (Tone)	Fresh Caustic (Tone)	Produced Red Mud (Tone)
Plant Feed	68.4	3.05	0.24*	2.55
Raw Low grade	42.5	5.86	0.87	5.92
Pilot ore dressed(d=2.3)	65.0	3.86	0.26	3.29

* With Secondary Causticization and Carbonate Recovery

This means that ore dressed Bauxite not only can be used directly as the plant feed without any further processing but also there will be some benefit in processing Jajarm Bauxite before use through:

(1) Removing a major amount of minerals with reactive Silica from plant feed, which is equal to reduction of 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) Five percent humidity of processed Bauxite can reduce notable problems due to Bauxite dust during carrying dry Jajarm Bauxite, storage, homogenization, handling and transport to ball mill, in a tangible way.
(4) Due to the higher density of Bauxite and using 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 behaviour in the thickeners and 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. In addition, the 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 mine, and carry to the Jajarm plant can be ore dressed in place, and then higher-grade bauxite will be economical to carry to Jajarm and used at the Alumina plant.

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. Techno-Economic feasibly study for establishing a 60 $\frac{t}{h}$ industrial plant carried out with IRR and NPV equal: 39.98 and 1,989,752$, respectively, as the result. Taking the k coefficient as 20 and 0, the return on investment of this project is 5 and 4 years, respectively.

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