

BAUXITE BENEFICIATION - OUR EXPERIENCE IN BALCO

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ABSTRACT

Bauxite is the only economic ore for the production of Aluminium. Bauxite consists of hydrated aluminium oxide in the mineral form of Gibbsite, Boehmite and Diaspore with impurities like Silica, Iron and Titania minerals and other minor minerals. Each industry has stringent specification in terms of physical and chemical composition. For economic production of alumina high trihydrate and low reactive silica content is desired to save steam energy and caustic soda consumption. The impurities in bauxite increase the cost of mining, handling and transportation. More importantly, they increase costs of downstream products because of waste handling and disposal. The impurities also reduce the capacity utilization, productivity and efficiency of the plant. Due to such problem, it is widely recognized that the bauxite ore should be purified (or beneficiated), preferably where it is mined, to remove iron and other impurities.

Indian bauxite deposits have been grouped into three major categories namely: East Coast Bauxite, Central India Bauxite and West Coast Bauxite. East Coast Bauxites are easily digested at low temperature and low pressure, West Coast Bauxite are digested at moderately high temperature and pressure whereas Central India Bauxites require high temperature and high-pressure technology. The Bauxite processed at Balco - Korba comes under the Central India Bauxite Group.

Beneficiation of Mainpat Bauxite which is prime source of raw material supply for alumina refinery of Balco at Korba, was carried out by Wet Processing, Dry processing, Magnetic Separation and combination of all the above. Our experience in Bauxite Beneficiation shall be discussed in details. The results indicate that simple wet / dry beneficiation would result in reduction of silica by 10 - 20% with nominal increase in alumina content. Magnetic Separation experiment has shown a substantial improvement both in the alumina increment and silica reduction along with reduction in iron content. The results will be discussed in details.

INTRODUCTION

Aluminum is known to be the most abundant element in the earth's crust. Bauxite is the only economic ore for the production of aluminium. India is fortunate to have abundant reserves of bauxite about 2.3 billion tones, which are the 5th highest bauxite reserves in the world. About 4-6 tonnes of bauxite are required to produce one ton of aluminium metal depending upon the grade of the ore. Around 85% of bauxite is used up in alumina making. Bauxite consists of hydrated aluminium oxide in the mineral form of Gibbsite, Bohemite and Diaspore with impurities like Silica, Iron and Titania mineral and other minor minerals. Bauxite is used in metallurgical, chemical, refractory, absorbent, cement, abrasive and building industries. Each industry has stringent specifications in terms of physical and chemical compositions. All Bauxites may be considered suitable for alumina and metal production when chemical composition alone is considered but there are definite considerations of mineralogical composition and nature of silica

present. For economic production of alumina, high trihydrate and low reactive silica content is desired to save steam energy and caustic soda consumption. Monohydrates with higher silica require high-pressure leaching and more caustic consumption. The impurities in bauxite increase the cost of mining, handling and transportation. The impurities in bauxite also reduce the productivity and efficiency of the Plant. Due to such problem, it is widely recognized that the bauxite ore should be beneficiated.

The beneficiation process adopted are decided by the nature of the components in terms of physical and chemical properties of the mineral components of the ore and gangue minerals and their mode of association with other. The method of exploitation and the end use of the beneficiated product also determine the techniques of processing schemes. There are two problems that make purification of bauxite difficult. Both are closely related to one another i.e. the wide and easy availability and low price of high and medium grade bauxite and the fine dispersion of iron oxides, Kaolinitic clays, calcium and titanium minerals in the crystalline aggregates of marginal or sub marginal bauxite ores. Most mines abroad subject their Run Of Mine ore (ROM) to the mineral dressing operation most suitable for their material. The various steps taken by the mines are in general as given below:

(a) **Manual Breaking and Sorting**

The bauxite mines in the country generally follow manual breaking and sorting. The components like limonite and clay ore softer than bauxite and on breaking the unwanted components, becomes finer than the wanted and thus the coarser lumps from the wanted product and the fines are the deleterious once and are comfortably rejected. The effective manual sorting can be carried up to 20 mm size only.

(b) **Mechanical Crushing**

This normally involves crusher and screen. In order to improve the quality of mine output, dry screening technique has to be employed to meet the quality requirements of the consumer. In case the dry operations do not improve the quality of bauxite to the desired level; wet screening has to be attempted. Tumbling and scrubbing operations has to be restored for removal of sticky clayey material.

(c) **Magnetic Separation**

Dry or Wet high intensity magnetic separation techniques are employed for removal of iron impurities in minerals like siderite or hematite.

(d) **Flotation**

The flotation processes are applied for reduction of Iron and Titania minerals.

EXPERIMENTAL WORK

The beneficiation study on Mainpat bauxite for Korba Alumina Refinery has been carried out in collaboration with Indian Bureau of Mines (IBM), Nagpur.

(a) **Beneficiation Study on Run of Mines (ROM) Bauxite**

The bauxite sample essentially consists of predominant amount of Gibbsite and Cliachite whereas Boehmite is in minor amounts, inter-mixed with Gibbsite / Cliachite and other Silicate minerals. Quartz, clay, Anatase and feldspar occurs as scattered grains within Gibbsite / Cliachite.

Mineral	Approximate %
Gibbsite + Cliachite + Boehmite	55 - 60
Kaolinite (Clay)	5 - 6
Anatase	7 - 10
Goethite + Limonite	20
Hematite	3 - 4
Quartz	1 - 2
Mica	2 - 3
Feldspar	1 (approx)

The process evolved for the reduction of Silica in the sample comprises of the following stage :

- I. Size reduction of big lumps to all - 75 mm size,
- II. Wet scrubbing of the sample,
- III. Wet scrubbing of the scrubbed material on the 10 mm opening Trommel attached to the scrubber.
- IV. Classification of Trommel undersize (- 10 mm) to separate coarse and slime fraction,
- V. A portion of classifier underflow was subjected to high force Magnetic Separator.
- VI. A representative portion of ROM was crushed to minus 10 mm (-10 mm) mesh and subjected to high force magnetic separation.
- VII. In order to recover water used in the circuit for recirculation, thickening tests were carried out on Classifier overflow (Slime) and the required thickener area was calculated employing laboratory sedimentation techniques (Kynch Method).

The Flow sheet and the results are given in **Annexure - I**.

(b) Beneficiation Study on Sorted Bauxite Sample :

The bauxite sample essentially consists of predominant amount of Gibbsite and Cliachite whereas Kaolinite and Anatase are in subordinate amounts. Goethite intermixed with Limonite is in major proportions in the sample. Hematite predominantly associated with Iron Oxide. Reactive Silica is contributed by clay.

The approximate percentage distribution of various minerals present in the samples is as follows:

Mineral	Approximate %
Gibbsite + Cliachite	50
Boehmite	5 - 7
Kaolinite (Clay)	7 - 10
Anatase	10
Goethite + Limonite	20
Hematite	4 - 5
Quartz	< 1

The details of the Trials on sorted bauxite samples are given below:

- Trial – I** : The process evolved comprises of the following stages :
- (i) Size reduction of big lumps to all minus 75 size,
 - (ii) Wet scrubbing of the sample
(Bauxite Feed - 20 kg / min.)
(Water Feed - 14 LPM)
 - (iii) Wet Screening by Trommel having 10 mm circular punched openings,
 - (iv) Classification of Trommel undersize (- 10 mm),
- Trial – II** : Same as Trial – I.
The results of Trial-I and Trial-II are given in **Annexure-2**.
- Trial – III** : The process of the Trial is given below :
- (i) Size reduction to minus 75 mm,
 - (ii) Wet scrubbing
(Bauxite Feed - 20 kg / min.)
(Water Feed - 14 LPM)
 - (iii) Screening by Trommel having 10 mm circular punched openings,
 - (iv) Crushed to all minus 1" size of minus 75 + 10 mm lumps and subjected to scrubbing at 45% pulp density and screened over 5 mm screen.
- Trial – IV** : Same as Trial – III.
- Trial – V** : Same as Trial – III.
- Trial – VI** : Same as Trial – III.
The results of Trials - III, IV, V, VI is given in **Annexure-3**.
- Trial – VII** : The process of the Trials for sorted bauxite is given below :
- (i) Size reduction to minus 75 mm,
 - (ii) Wet scrubbing
(Scrubbing Feed Rate – 20 kg / minute, Feed Water - 24.45 LPM,
Pulp Density - 45%),
 - (iii) Screening by Trommel with 10 mm,
 - (iv) Crushed to all minus 1" size of minus 75 + 10 mm lumps and subjected to scrubbing at 45% pump density and screened over 5 mm screen.
 - (v) A portion of minus 75 + 10 mm scrubbed lumps was crushed to all minus 1" size and subjected to scrubbing & deslimed.
 - (vi) The washed Trommel undersized (-10 mm) passed through Classifier. The Classifier products are overflow and underflow.
 - (vii) In order to recover water, used in the circuit, for recirculation, thickening tests were conducted on Classifier overflow and the required thickener area was calculated employed standard Laboratory Sedimentation techniques.

The Flow Sheet and the results are given in **Annexure – 4**.

- Trial-VIII : The process of the Trial comprises following stages :
- (i) A representative sample of +25 mm sorted lumps was subjected to scrubbing of 45 % Pulp density.
 - (ii) The sand fraction obtained was again subjected to scrubbing at 45 % pulp density and the scrubbed material was deslimed.

The Flow sheet and the results are given in **Annexure - 5**.

CONCLUSIONS

From the results it is seen that the second stage washing does not yield great benefits as SiO₂ is sitting in the Ferruginous lattice Magnetic Separation would yield in better reduction of silica compared to simple grinding and washing with a yield less than 50%. This would lead to shortening of mine life. Hence a single washing after crushing to 75 mm would yield the maximum benefit and increase mine life.

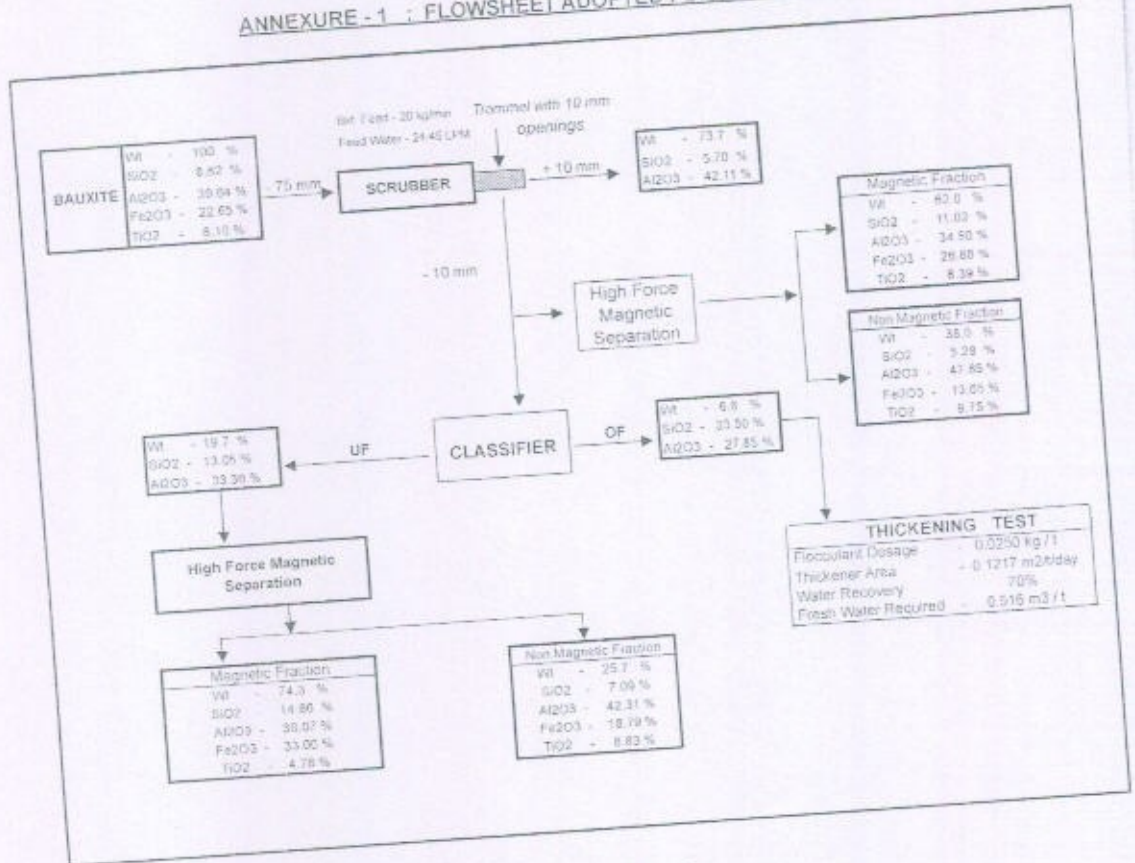
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ANNEXURE - 1 : FLOWSHEET ADOPTED FOR ROM BAUXITE



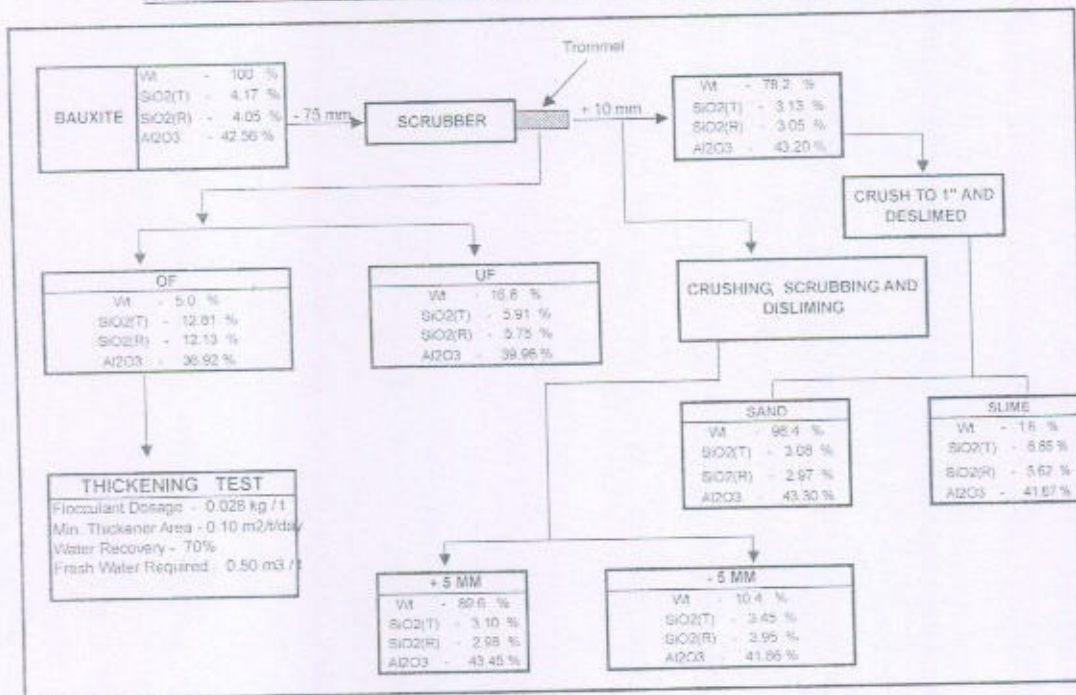
ANNEXURE - 2
RESULTS OF SORTED BAUXITE

		BAUXITE	TROMMEL + 10 MM	CLASSIFIER		REMARKS
				OF	UF	
TRIAL - I	Wt %	100	78.2	5.00	16.80	Recovery - 78.20 % Redn. In SiO ₂ (T) - 24.94 % Redn. In SiO ₂ (R) - 25.93 %
	SiO ₂ (T) %	4.17	3.13	12.81	5.91	
	SiO ₂ (R) %	4.05	3.00	12.13	5.65	
	Al ₂ O ₃ %	42.56	43.20	36.92	36.96	
TRIAL - II	Wt %	100	78.00	6.60	15.40	Recovery - 78.00 % Redn. In SiO ₂ (T) - 23.24 % Redn. In SiO ₂ (R) - 22.22 %
	SiO ₂ (T) %	4.26	3.27	11.70	5.67	
	SiO ₂ (R) %	4.05	3.15	9.64	5.25	
	Al ₂ O ₃ %	41.72	42.31	37.92	38.96	

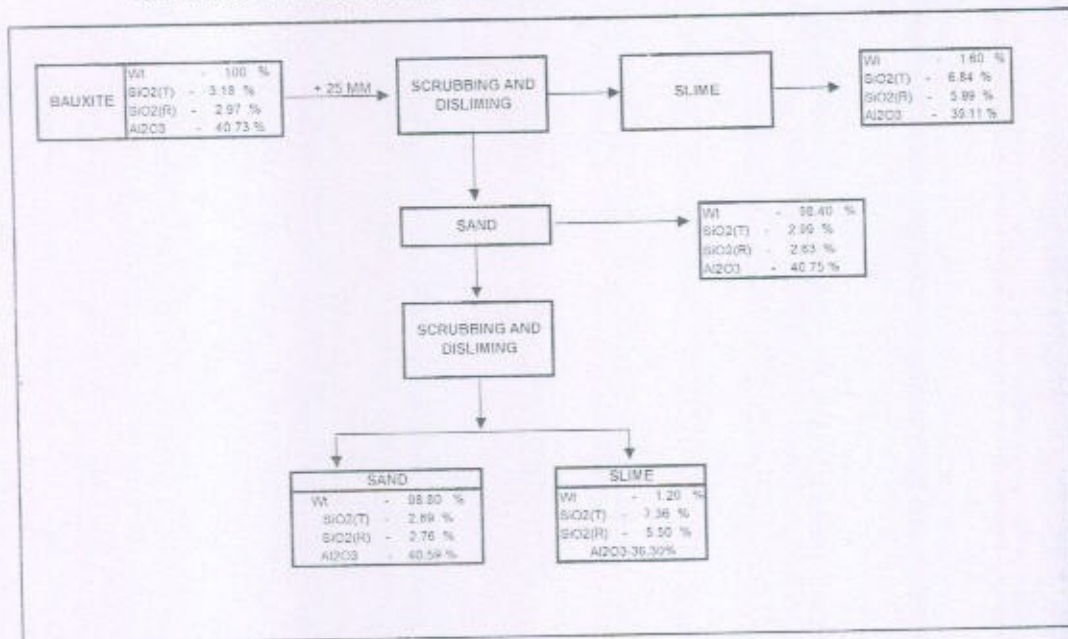
ANNEXURE - 3
RESULTS OF SORTED BAUXITE

	BAUXITE	TROMMEL			CLASSIFIER		REMARKS
		+ 10 MM	SCREEN		OF	UF	
			+ 5 MM	- 5 MM			
TRIAL - III	Wt %	77.20	69.20	8.00	4.50	18.30	Recovery - 53.42 %
	SiO ₂ (T) %	4.00	3.02	3.25	9.09	5.76	Redn. In SiO ₂ (T) - 27.58 %
	SiO ₂ (R) %	3.84	2.36	2.60	8.08	5.68	Redn. In SiO ₂ (R) - 41.73 %
TRIAL - IV	Al ₂ O ₃ %	43.09	43.13	42.77	39.00	39.65	Recovery - 69.17 %
	Wt %	77.20	89.60	10.40	4.50	18.30	Redn. In SiO ₂ (T) - 45.77 %
	SiO ₂ (T) %	2.64	2.18	2.34	10.42	5.67	Redn. In SiO ₂ (R) - 46.53 %
TRIAL - V	SiO ₂ (R) %	2.50	2.08	2.72	8.53	5.68	Recovery - 61.20 %
	Al ₂ O ₃ %	43.85	42.81	42.77	36.64	39.65	Redn. In SiO ₂ (T) - 27.55 %
	Wt %	62.20	98.40	1.60	6.80	31.00	Redn. In SiO ₂ (R) - 39.85 %
TRIAL - VI	SiO ₂ (T) %	3.21	3.05	6.85	3.90	5.70	Recovery - 61.20 %
	SiO ₂ (R) %	3.01	2.46	5.62	2.98	5.22	Redn. In SiO ₂ (T) - 47.78 %
	Al ₂ O ₃ %	40.39	40.22	38.14	36.41	37.41	Redn. In SiO ₂ (R) - 43.51 %
TRIAL - VI	Wt %	62.20	98.40	1.60	6.80	31.00	Recovery - 61.20 %
	SiO ₂ (T) %	2.82	2.47	7.28	9.06	4.62	Redn. In SiO ₂ (T) - 47.78 %
	SiO ₂ (R) %	2.74	2.35	5.76	7.51	4.36	Redn. In SiO ₂ (R) - 43.51 %
	Al ₂ O ₃ %	42.20	42.36	37.80	37.06	39.62	

ANNEXURE - 4 : FLOWSHEET ADOPTED FOR SORTED BAUXITE SAMPLE



ANNEXURE - 5 : FLOWSHEET ADOPTED FOR + 25mm SORTED LUMPS (BY HAND)



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The cliach bearin upgrac scrubt underl 44% A

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