CHAPTER 10

USES, SPECIFICATIONS AND CONSUMPTION OF BAUXITE

10.1 USES

The term "Bauxite" dates back to 1821, when the French Professor Berthier discovered a deposit of red earthy material outcroping near the village of Les Baux in Southern France. The Chemical analysis of this deposit revealed the presence of aluminium oxides, iron oxide and water. The name "Bauxite" was given to this red earthy material by Dufrenoy in 1837. The bauxite is the product of weathering and leaching of a variety of sediments or rocks, generally in a high rainfall tropical or sub-tropical climate, resulting in the enrichment of aluminium oxide content.

The principal ore forming minerals of bauxite are (i) Gibbsite (Al_2O_3, 3 H_2O) (ii) Boehmite (alpha monohydrate, Al_2O_3 H_2O) and (iii) diaspore (Beta monohydrate, Al_2O_3 H_2O). Besides principal ore forming minerals bauxite contains other minor constituent minerals such as corundum, cliachite, sporogellite, gibbritogellite, alumogel, silicagel, etc. The other mineral impurities are clay (Kaolin), hematite and or goethite (Iron oxide), anatase (Titanium oxide) and silica & quartz. A variety of minor elements may be present, such as calcium, magnesium, phosphorous, vanadium, gallium, manganese[1,2,3].

Bauxite is used as the main raw material for alumina making, which in turn is utilised for aluminium manufacturing. More than 90 percent of the world production of bauxite is consumed in the aluminium industry[2,4].

Among the metals, aluminium plays a major role in the modern world through its inumerable applications. In utility its position today is next to steel due to intrinsic properties of lightness, strength to weight ratio, corrosion resistance, electrical and thermal conductivity and non-toxicity etc. Further, due to non-availability of some other non-ferrous metal such as copper, lead and zinc the aluminium has taken a significant position in the world market today[5,6].

Now a days aluminium and its products are largely used in building construction, for doors, windows, screening, roofing, siding and railings etc. In the field of transportation, aluminium alloys are used in the construction of automobiles, air-craft, satellites and moon rockets. In electrical industry, aluminium require to manufacture the machinery and equipments of all kinds including cable and wire require for power transmission.

Aluminium and its products are also used in packaging chemical, petrochemical and other industries. Aluminium powder is used in explosive, rocket fuels and paints. Besides, it is used in household foils, manufacturing cooking utensils, furniture, toys, air conditioners and appliance of hardwares etc[7].

Bauxite is a prime important raw material for the primary aluminium industry. It is also used in a number of non metallurgical sectors, like refractory, abrasive, cement, steel making and chemicals[8].

In minor quantity bauxite is also used in the manufacture of aluminous chemicals for use in various industries such as dyeing, printing, tanning water purification and sewage treatment. A few of the important chemical products are aluminium sulphate (Alum), aluminium fluoride, aluminium acetate, aluminium hydroxide, and sodium aluminate. Besides, bauxite is commonly used as an absorbent in the refining of petroleum product particularly kerosene[7].

It has also been tried as road making material and used as a building stone[7].

10.1.1 METALLURGICAL INDUSTRY

By and large, bauxite is the only raw material from which aluminium is extracted economically.

The conventional route for the production of aluminium metal is in two stages. First the Bauxite is converted into alumina by bayer's process, which is further smelted electrolytically in the Hall - Heroult plant, to produce aluminium.

In the above process, 4 to 5 tonnes of dried bauxite yield some 2 tonnes of alumina which in turn give one tonne of aluminium metal[2,3,9].

The major applications of aluminium and aluminium based alloys are in (a) Electrical Engineering (b) Building and construction (c) Transportation (d) Containers and packings[10].

The electrical sector is the main sector consuming large quantities of aluminium especially when aluminium replaced copper in overhead Transmmission net work due to its lower price and relatively lower weight as compared to copper.

In India Electrical sector accounts for more than 50 per cent of the consumption whereas in Japan and USA it is 10 and 11 per cent respectively. In the electrical sector Aluminium is used in the manufacture of cables and conductors, power generation, transmission and transforming equipments, turbogenerators, switch gears, transformers, mortors, tube-lights and light fixtures etc. In electronic sector, aluminium is used in paper capacitors, Radio transistors, T.V. Sets, and also T.V. antenna etc[11,12].

The use of aluminium in building varies from one country to another and is partly influenced by climatic conditions. Utilisation of aluminium in extruded or rolled sections for window frames, curtain walls, gutters and roof flashings is commonly seen now a days.

In the Transportation sector, which consuming aluminium is remarkable and aluminium based alloys are used for manufacturing transport vehicles bodies, scooters, and motor cycles, Aircraft, Rail coaches, fittings etc.

In a containers and packing sector accounts about 28 percent aluminium is used in USA, whereas in India it is

about 6 percent. The proportion of non-toxicity, durability and thermal characteristics makes aluminium favourite in packing and canning industry. In the industry aluminium is used in variety of forms such as flexible or semi rigid foils and rigid all aluminium containers etc.

10.1.2 CHEMICAL INDUSTRY

Bauxite as well as alumina both are used in the manufacture of aluminium chemicals. The direct use of bauxite for chemicals is in the production of aluminium sulphate which finds its use as flocculating agent in water and effluent treatment. The other selected aluminium chemicals are :- (a) Aluminium Chloride, anhydrous ($AlCl_3$), Hexahydrate ($AlCl_3 \cdot 6 H_2O$) used as Catalyst in organic reactions, metallurgical and metal finishing applications (b) aluminium fluoride used as flux in remelting and refining aluminium and aluminium alloys, opacifier aid in glass enamels and ceramics, (c) Aluminium nitrate, monohydrate for salting out agent in the extraction of actinides, (d) Aluminium tristearate being used as textile finishing agent, lubricating grease, Gelling agent, (e) Sodium alumanite used for industrial water treatment etc[2,8,13].

10.1.3 REFRACTORY INDUSTRY

Bauxite is used as raw material in making refractory products since it has a high melting point from 1740°C to 1820°C. This is mainly depending upon the mineralogical composition. Some refractories are made from pure alumina derived from processing metallurgical grade bauxite but at large, the calcined bauxite is used. The principal use for refractory grade bauxite is in the production of high alumina refractories containing 75 to 90% alumina. These are used in the manufacture of bricks to line the roofs of electric arc steel making furnaces, blast furnaces, stoves, ladles and similar uses.

Alumina refractories find use in a number of non-ferrous industries like aluminium melting furnances for the manufacture of aluminium alloys and in such cases high alumina bricks are used for the floor and side walls of the furnace.

As far as copper industry is concerned, the high alumina refractories are some times used in reverboratory furnaces. Moreover the cement and glass industry also uses high alumina refractories[2,8,12,14].

10.1.4 ABRASIVE INDUSTRY

The other important non-metallurgical use of this mineral is in abrasive industry. The abrasive grain is produced by the fusion of either chemically purified alumina or calcined bauxite. In both the cases, the fusion is done in electric arc furnace to produce abrasive grain. The product derived from the chemically purified alumina is known as white corundum and on the other hand the fused calcined bauxite is termed as brown fused alumina.

The brown fused alumina accounts for about 80 percent of fused alumina used in abrasive industry. It is used as bonded and coated abrasive such as grinding wheels, sheets, belts and mops. The fused alumina is useful for grinding high strength materials such as steel bronze and hard woods.

The white fused alumina abrasive tend to be used in loose abrasive application such as grinding and polishing especially in the optical polishing field[8,12,13].

10.1.5 CEMENT INDUSTRY

The high alumina cement is manufactured by mixing selected quality of bauxite and limestone, whereas portland cement uses clay or shale instead of bauxite. This type of cement is with high alumina content and possess better properties than portland cement. High alumina cement are known for their quality of rapid setting times which usually takes as less as 2 to 4 hours and strong strength achived after 24 hours. It has also very high resistance to corrosion due to chemical action by salt water and other aggressive liquors. In addition to it is also resistant to sulphates and dilute acids presents in the soil and thus has been useful in concrete piles, tunnels and masonry exposed to water[3,8,11,13].

10.1.6 ABSORBENT INDUSTRY

Activated bauxite is used as a drying agent for gases and organic liquids and therefore it is suitable to use in petroleum industry. When low iron gibbsite $Al(OH)_3$ is roasted at low temperature of around 400°C, it drives off the two of the three water molecules of combined water to leave a residue of coarse abrasion resistant particles. This being a reversible process, the activated material combines with water. This product is characterised by high surface area which contributes to its reactivity and its use as an absorbent for a number of other compounds based on elements such as sulphur and fluorine. It has also limited uses in the areas of catalysis and filtration[3,11,13].

10.1.7 STEEL INDUSTRY

In Steel industry the principal use of bauxite is in iron making where it is added to control the desulphurising power and fluidity of the slag and at the same time provide material for blast furnace cement. It is also used in steel production in the basic oxygen furnace as an additive so as to control the viscosity of the slag. Normally, fluorspar has been one of the principal flux additives, but the potential release of fluorine in exhaust gases into the atmosphere causes a great concern. Hence, the bauxite has been used as a source of alumina to control the viscosity.

10.1.8 BUILDING STONE AND ROAD AGGREGATES

If no other building material is available lateritic bauxite comes handy substitute as building material. A small quantity of calcined bauxite is also used as antiskid road aggregate. Even though this is most expensive form of road aggregate, it may be used in strategic locations to prevent accidents. Bauxite has been used in the form of blocks to break the waves in Marmagao horbour[3,8,10].

10.1.9 OTHER USES

Bauxite is also being used in several other sectors viz. in rubber, plastic, cosmetics and paint industry as a filler. Calcined bauxite is somtime used as welding flux

compositions in submerged arc welding. Fine grades alumina trihydrate in small quantities are used in paper industry as additives. In the production of high alumina ceramics, the calcined aluminas are used[2,11,13].

10.2 SPECIFICATIONS

The utilisation of bauxite for alumina depends on various factors. There are economics, location strategy, and national policies. Though high recoverable alumina contents and low percentage of deleterious constituents are desirable in bauxite used for aluminium. On the other hand the bauxite used for making refractories, abrasive and chemical must meet the rigid compositional requirements. In making alumina, while the principal minerals plays a very significant role during the leaching process, other mineral increased the volume of the waste burden. The more the waste burden in the feed, the lesser will be productivity of the alumina plant, entailing a higher production cost. The industry wise specification and the impact of deleterious constituents have been summarised in the following paragraphs[2,14].

Impact of deleterious constituents :

Various chemical constituents of bauxite that affect alumina making are silica, iron compounds, titania, vanadium phosphorous and magnesia, etc[3].

Silica

The silica in bauxite is of two types - reactive and non reactive. Non reactive silica is that which does not participate in the chemical reactions and is present in form of quartz and chalcedony etc. Reactive silica occurs in the chemically combined form in clay and other silicates.

In the Bayer process for alumina making, reactive silica forms hydrous sodium-alumino-silicates during digestion by soda, at temperature 80 to 90°C, as per the following reactions :

$$SiO_2 + 2NaOH = Na_2SiO_3 + H_2O$$

$$2Na_2SiO_3 + 2NaAlO_2 + 2H_2O = Na_2O Al_2O_3 + 2SiO_2 + 4NaOH$$

This compound ($Na_2O\ Al_2O_3$) forms a part of red mud rejects and thus causes loss of caustic soda as well as alumina. In practice, it has been observed that for every one gram increase of silica content in bauxite, there is a loss of 0.5 to 0.7 gm of Na_2O and 0.85 to 2.0 gm of Al_2O_3.

Since the non reactive silica is chemically in-active it does not react in the Bayer process and is thus rejected as such in the red mud. The only consequence of the bauxite presence is that it adds to the waste burden.

Bauxite with more than 7 percent of total silica is normally unsuitable for use in Bayer process for alumina making and silica content below 3 percent is generally preferred. Silica present in the ore directly affects the production cost of alumina because of increased consumption of soda and higher loss of alumina in the red mud. The requirement of soda and other raw materials at different percentages of SiO_2 and Al_2O_3 for producing one tonne of alumina as estimated by Bracewell is given below :

Raw material		Bayer process at			
		SiO_2 3%	Al_2O_3 55%	SiO_2 13%	Al_2O_3 50%
Bauxite(dry)	(Tonnes)	2.0		3.0	
Soda	(Kg)	80		400	
Lime	(Kg)	60		300	
Natural gas	(cu.m.)	251		279	

At 13 percent SiO_2 and 50 percent Al_2O_3, the consumption of raw material for the combination of Lime Sinter and Bayer processes is significantly less compared to that for the Bayer Process alone except in case of limestone and natural gas. The reason being that a partial recovery of alumina and soda from red mud is possible in the former process.

Iron compounds

Iron occurs in bauxite as oxides. Ferric oxide (Fe_2O_3) does not participate in the chemical reactions and passes directly to the red mud in the Bayer treatment. Therefore, the only significance of its presence is that it adds to the quantity of waste which results in additional transport and handling problems and also affects productivity.

Iron carbonate during treatment is reduced to FeO and CO_2. The reaction also results in a higher consumption of soda since CO_2, reacts with it. During the Bayer process, FeO forms colloidal iron which makes the filtering process difficult. Rotting on filter cloth also takes place leading to ineffective filtration and thereby the iron and silica contents in the refined alumina go up.

Titanium

Titanium oxide (TiO_2) does not go into solution during Bayer treatment and thus gets eliminated in the red mud. If little quantities of titania passes to alumina due to poor filtering and consequently to aluminium, the electrical qualities of the electrical grade aluminium is seriously affected.

Vanadium

Vanadium is not entirely eliminated during the Bayer process in the residue and passes into the filtrate. Thus, it appears as deleterious constituent in aluminium metal. In fact, for E.C. grade metal, vanadium content should not exceed 0.02 percent.

Phosphorus

Phosphorus present in bauxite in high amounts goes into solution during digestion in the Bayer process. Thus, it gets mixed up with the alumina produced and the presence of bauxite is considered detrimental to the reduction process.

Magnesia

In Magnesia bauxite occurs only in traces, if any, in bauxite but is never passed into alumina.

Organic material

If bauxite with a higher content of organic compounds is used over a long period in alumina making, their concentration in the liquor progressively increases making it darker in colour. It also increases its viscosity causing froth formation. Thus, settling of the digesting slurry, evaporation of spent liquor and the separation of salts become difficult. Further, it results in hard scale formation and causes hindrance in the growth of hydrate grains.

Higher digestion temperature helps in decomposing the organic matter.

Moisture

For practical reasons, it is better to feed Bayer plant with dry bauxite since this maintains uniform feed to the digester. It also eliminate the variations in alumina content for the same quantity of bauxite fed to the plant.

10.2.1 METALLURGICAL INDUSTRY

The specification of bauxite for the production of alumina by the Bayer's process is given below. Other than this, the mineralogical character of bauxite has a bearing on its digestion in caustic soda. The monohydrate requires high temperature and higher concentration of soda while the trihydrate variety is digested at low temperature and lower concentration[14].

The ISI has prescribed the following specification of bauxite for production of alumina by Bayer process (IS : 5953 - 1985)

Constituent	Percentage by weight	
	Grade I (Essentially gibbsitic or trihydrate)	Grade II* (Mixture of gibbsite and boehmite plus diaspore) or trihydrate and monohydrate
Total Al_2O_3, Min	40	47
Total available Alumina (TAA), Min	36	43
Total SiO_2, Max,	4	4
Module, Min (Al_2O_3/SiO_2)	12	12
$Fe_2O_3 + TiO_2$ Max	30	30
P_2O_5, Max	0.20	0.20
V_2O_5, Max	0.20	0.20
Loss on Ignition at 1100°C, Min	20	20

*Normally 1 to 2 percent diaspore and 5 to 7 percent boehmite.

Now there is a trend to use bauxite with lower percentage of Al_2O_3 provided that it has low content of reactive silica and an acceptable limit of monohydrate bauxite. For example, NALCO has reported that they would be using in their plant bauxite containing 42 percent Al_2O_3 and less than 4 percent reactive silica[14].

The specification of bauxite consumed in important aluminium industry in respect of six plants are summerised in table No.10.1. Of the industry, the BALCO, HINDALCO and INDAL (Belgaum) are using bauxite having more than 47 percent Al_2O_3 and the remaining plants consumes less than 45 percent Al_2O_3. The silica percentage is higher in INDAL (Belgaum) and MALCO, (Mettur) compared to other plants.

TABLE 10.1 : SPECIFICATIONS OF BAUXITE CONSUMED IN IMPORTANT ALUMINIUM INDUSTRY

Sl. No.	Name & Address of Consumer	Purpose for which used	Specifications
1.	BALCO, Korba Distt. Bilaspur, M.P.	For extraction of Aluminium	Total Alumina - 47.40% min. Total Silica - 3.8% max. Module - 12.48 Combined oxide (Fe_2O_3 & TiO_2) 26.24% LOI 23.54%
2.	HINDALCO Renukoot Distt. - Sonbhadra, U.P.	- do -	Physical sp.gr. 2.54 Chemical Al_2O_3 - 48.50% SiO_2 - 2.9-3.5% H_2O - 2.5-3.5% Fe_2O_3 - 13-15% TiO_2 - 8.5-9% CaO - 0.25-0.35% P_2O_5 - 0.25-0.27% V_2O_5 - 0.20-0.24% LOI - 23-24% (dry basis)
3.	NALCO, Dhamanjodi Distt. Koraput, Orissa	- do -	Gibbsite Al_2O_3 - 42.5% SiO_2 - 1.65% (reactive) SiO_2 - 0.65% (non reactive) Fe_2O_3 - 25.6%

Contd/..

Sl.No.	Name & Address of Consumer	Purpose for which used	Specifications
4.	INDAL, Chotamuri Distt. Ranchi, Bihar	For extraction of Aluminium	Gibbsite - 35-45% Boehmite - 1 -12% Total silica - 1.5-4.5% R.Silica - 1.2-3.8% TiO_2 - 8 -19% Fe_2O_3 - 6 -18% V_2O_5 - 0.1-0.15% Moisture - 6 -12% LOI - 23-26%
5.	INDAL, Belgaum Karnataka	-do-	Al_2O_3 (by diff) 48% SiO_2 - 5% Fe_2O_3 - 17.62% TiO_2 - 5.72% V_2O_5 - 0.15% LOI - 24.67%
6.	MALCO Mettur dam,	-do-	Physical Colour-Brick Red Sp.gr. - 2.620 Al_2O_3 - 44.16% T.SiO_2 - 6.07% Sol.SiO_2 - 3.88% TiO_2 - 1.75% Fe_2O_3 - 23.70% K_2O - 1.26% CaO - 0.11% LOI - 23.96%

10.2.2 CHEMICAL INDUSTRY

The chemical constituents to be considered for chemical grade would be Al_2O_3 and Fe_2O_3. The chemical grade bauxite should have Al_2O_3 58 percent minimum and Fe_2O_3 2.5 percent maximum[14].

The main criteria for chemical grade bauxite is that the acid soluble iron oxide should be as low as possible. Iron causes settling difficulties and it is also difficult to remove when it is in solution.

Further, the normal specification for chemical grade bauxite requires an Al_2O_3/ Fe_2O_3 ratio of 23/1 or higher. This ratio imparts as acceptable pale straw-yellow colour to the solution as used by the most of the consumer.

Other constituents are normally not of great importance and silica levels upto 10 percent can be tolerated. The insoluble silica causes settling difficulties, also poor filtering and retards chemical reactions[2,14,15].

The specification of bauxite consumed in 5 important units are given in table No.10.2. M/s Bengal Chemicals & Pharamaceutical and M/s C.D. Thakkar & Co. uses bauxite containing 60 percent Al_2O_3. It may also be seen that the Fe_2O_3 contents ranges from 1 to 3 percent.

10.2.3 REFRACTORY INDUSTRY

Bauxite is used in the refractory industry with a view to increase the alumina content in refractory mixture which consequently improves the properties of the refractory bricks. The ore of bauxite for refractory use must be generally high in alumina content, with low iron oxide 2.5% after calcination and low titanium dioxide 4 percent maximum. Silica contents exceeding 10 percent may acceptable but it should be present mainly as a clay mineral and not as quartz.

The diaspore variety is preferred although gibbsite or a mixture of monohydrates can also be used for the manufa-

TABLE 10.2 : SPECIFICATIONS OF BAUXITE CONSUMED IN IMPORTANT CHEMICAL INDUSTRY

Sl.No.	Name & Address of consumer	Purpose for which used	Specifications	
Allum (ferric & iron free)				
1.	Bengal Chemical & Pharamaceutical Works Ltd., Calcutta, W.B.	Raw mineral providing alumina	Al_2O_3	- 60% min.
			Fe_2O_3	- 2% max.
			SiO_2	- 1%
			TiO_2	- 1%
2.	Dharamsi, Morarji Chemicals Ambarnath, Thana, M.S.	- do -	Al_2O_3	- 52% min.
			Fe_2O_3	- 1-2.5% max.
			SiO_2	- 1% max.
			TiO_2	- 1-3% max.
3.	DharamsiMorarji Chemicals Kumhari, Durg, M.P.	- do -	-do-	
4.	Phosphate Co,Ltd. Rishra, Hoogly, W.B.	- do -	Size 20 cm Lumps Al_2O_3	- 56% min.
			Fe_2O_3	- 3% max.
	Alum (ferric)			
5.	C.D. Thakkar & Co. Calcutta, W.B.	- do -	Al_2O_3	- 60%
			Fe_2O_3	- 3% max
			SiO_2	- 3% max
			TiO_2	- 4% max.

cture of refractory. Iron oxide and titanium dioxide are most deleterious constituents. Excess of iron content causes deformation and warping in the refractory products. Similarly, alkalies and lime causes fusion at low temperature[2,8,14].

The ISI (IS10817 - 1984) has prescribed the following composition of bauxite for its use in refractory industry[16]. :

Composition of Bauxite

Constituent	Percent
Al_2O_3	58, Min.
Fe_2O_3	3, Max.
TiO_2	3, Max.
CaO	0.5 - 0.6
Loss of ignition	27 - 30

There are 5 important refractory industries and the specification of bauxite consumed by these units are given in table No.10.3.

10.2.4 ABRASIVE INDUSTRY

In the manufacture of abrasive, silica in bauxite is the most undesirable constituents. Excess of silica causes high consumption of power and carbon and also causes erratic furnace operations and poor control of the chemical reactions involved. Silica also forms ferro silicon alloy with iron which is non magnetic and can be separated magnetically from the product.

There is no ISI Specification, however the specification of bauxite in four important units are given table No.10.4. It may be seen from the table that the user industries prefer Al_2O_3 50 percent (min), SiO_2 2.5 to 3 percent, Fe_2O_3 3.5 to 12 percent, TiO_2 3 to 4 percent.

TABLE 10.3 : SPECIFICATION OF BAUXITE CONSUMED IN IMPORTANT REFRACTORY INDUSTRY

Sl.No.	Name & Address of consumer	Purpose for which used	Specifications
1.	ACC Refractory Works Katni, M.P.	As one of the body constituents to increase alumina content and refractoriness of product mix.	PCE - 34 Min. Al_2O_3 - 56-60% Fe_2O_3 - 4.5% max. CaO - 0.7% max. TiO_2 - 2.5 - 3.5%
2.	Orissa Cement Refractory Unit, Sundargarh, Orissa	- do -	Al_2O_3 - 59% min. CaO - 1% max. Fe_2O_3 - 2.5% max. TiO_2 - 4% max.
3.	Orissa Industries Ltd., Berang, Orissa	- do -	PCE - 38 Sp.Gr. - 3.7 Al_2O_3 - 68% Fe_2O_3 - less than 2% SiO_2 - 2.5% max.

Sl.No.	Name & Address of Consumers	Purpose for which used	Specifications
4.	Valley Refractories Maithan Road, Dhanbad, Bihar	As one of the body constituents to increase aluminium content & refractoriness of product mix.	Diaspore & Others Grade — Physical GD = 3.33 gms CC - (3.1 to 3.33) % AP = 14.7 (14.7-18.1) % WA = 4.4 (4.4 -5.8) A.Sp.gr. = 3.91 (3.82-3.91) Al_2O_3 - 74-75% CaO - 0.15% SiO_2 - 4.5% (non-reactive) Fe_2O_3 - 8-10% TiO_2 - 10-12%
5.	VRW Refractories Vanagram, Madras	- do -	Hard burnt bauxite Lumps Al_2O_3 - 85% SiO_2 - 2% (reactive) SiO_2 - 2% (non-reactive) CaO - 0.5-2.0 Fe_2O_3 - 2% TiO_2 - 2.5-3.0%

SOURCE : Directory, of Mineral Consumers in India
Vol. I, 85-91, IBM, Nagpur.

TABLE 10.4 : SPECIFICATIONS OF BAUXITE CONSUMED IN IMPORTANT ABRASIVE INDUSTRY

Sl.No.	Name & Address of consumers	Purpose for which used	Specifications
1.	Carborandum Universal Madras	For abrasive grains	Calcined bauxite Size : +10 mesh-50% max. -60 mesh-20% max. Al_2O_3 - 86% CaO - 0.8% TiO_2 - 3.6-4% Fe_2O_3 - 4.5% SiO_2 - 2.5% LOI - 1%
2.	Emery (India) Pvt.Ltd. Jamnagar, Gujarat.	- do -	size : 7.5 to 10 cm lumps Al_2O_3 - 50% Fe_2O_3 - 10-12%
3.	Indian Abrasives, Industrial Area, Faridabad, Haryana	Used for making abrasive cloths, belts, discs, rolls.	Al_2O_3 - Above 50% Fe_2O_3 - 10%
4.	Orient Abrasive Ltd. New Delhi	For manufacture of fused alumina and calcined bauxite.	Al_2O_3 - 60% min. Fe_2O_3 - 3.5% max. SiO_2 - 3% max. TiO_2 - 3% CaO - 0.5% max.

Source : Directory of Mineral Consumers in India
Vol. 1 PP 71-72, IBM, Nagpur.

10.2.5 CEMENT INDUSTRY

There are no specification of bauxite for use in Cement industry. However, small quantities of bauxite reported to have been used in the raw meal blend to correct imbalance of silica modules. In cement industry, one of the parameters used in selection of raw materials is the silica modules defined as % SiO_2 / % Al_2O_3 + Fe_2O_3) and the preferred range of this value is between 2.6 and 2.8 with the alumina content exceeding the iron oxide. In the manufacture of high alumina, high iron cement a typical specification is minimum Al_2O_3 : SiO_2 ratio of 10:1 and an Al_2O_3: Fe_2O_3 ratio of 2 to 2.5 : 1[2,13].

The table 10.5 indicates the specifications of bauxite consumed in 8 important cement factories and this is used for balancing the alumina, iron and Silica contents of the clinker.

10.2.6 ABSORBENT INDUSTRY

The ISI (IS 305 - 1984) has prescribed following specifications for chemical and petroleum industries.

Sl.No.	Characteristics	Requirement
(i)	Loss on ignition, percent by mass, Max.	32.0
(ii)	Silica (as SiO_2), percent by mass max.	3.0
(iii)	Alumina (as Al_2O_3), percent by mass min.	58.0
(iv)	Iron Oxide (as Fe_2O_3), percent by mass, max.	2.0
(v)	Titania (as TiO_2), percent by mass, max.	4.0
(vi)	Phosphorous pentaoxide (as P_2O_5), percent by mass, max.	0.3
(vii)	Manganese oxide (as MnO), percent by mass, max.	0.1
(viii)	Calcium and magnesium (as CaO), percent by mass, max.	2.0

TABLE 10.5 : SPECIFICATIONS OF BAUXITE CONSUMED IN IMPORTANT CEMENT INDUSTRY

Sl.No.	Name & Address of consumer	Purpose for which used	Specifications
1.	ACC, Kymore, Jabalpur, M.P.	For balancing the alumina, iron and silica contents of the clinker	Laterite - Small lumps Fe_2O_3 - 30 - 35%
2.	ACC, Mancherial, Adilabad, A.P.	- do -	Laterite - Lumps Fe content 35 - 40%
3.	Birla Cement, Chittorgarh, Rajasthan	- do -	Laterite - 25 mm lumps Fe_2O_3 - 24.1% Al_2O_3 - 18.8%
4.	CCI, Bokanjan, Karbi Anglong, Assam	- do -	Bauxite Al_2O_3 - 45% approx. Fe_2O_3 - 5% max
5.	CCI, Kurukunta, Gulbarga, Karnataka	- do -	Laterite / Bauxite Fe_2O_3 - 24-27% / 14-17% Al_2O_3 - 29-32% / 48-50% SiO_2 - 30-40% / 7- 9%
6.	Kesoram Cement, Basant Nagar Karimnagar, A.P.	- do -	Bauxite - bright red coloured Al_2O_3 - 50-55% Laterite - red coloured Fe_2O_3 - 45-50%

Contd/..

Sl.No.	Name & Address of Consumer	Purpose for which used	Specifications
7.	Panyam Cement Kurnool, A.P.	For balancing the alumina, iron and silica contents of the clinker	Gibbsite - Lumps Al_2O_3 - 42.43% SiO_2 - 11.20% (reactive) CaO - Traces Fe_2O_3 - 19.2% TiO_2 - 3.0% LOI - 23%
8.	Udaipur Cement, Bajajnagar, Udaipur, Rajasthan.	- do -	Laterite - Size : 5 mm Fe_2O_3 - 32-37% Al_2O_3 - 22-24%, SiO_2 - 24-26% CaO - 1 -3% LOI - 12-14%

It may be seen from the above that the alumina content of the ore is as high as 58 percent. In fact, the U.S. Stock-pile specifications also recommend a high alumina trihydrate for use as an absorbent in petroleum refining. The reason for using only trihydrate is that its absorptive capacity is 3 to 4 times more than monohydrates. For practical reasons, hard, gravelly and pisolitic ore is preferred since it does not disintegrate and pack in the absorbeing towers[3,14].

10.2.7 STEEL INDUSTRY

Bauxite is used in both iron and steel industry for making as a slag adjuster. In general, the specification of bauxite required are Al_2O_3 - 55 percent ; SiO_2 less than 7 percent, strict specification with regard to phosphorous and sulphur which should not be present however trace amount is allowed, low moisture content, and size from 10 to 50 mm[2,13].

The specification of bauxite consumed in 3 units are given in table 10.6 The Al_2O_3 content ranges from 50 to 55 percent.

10.3 CONSUMPTION OF BAUXITE :

The consumption statistics of bauxite in different consuming industries during 1975 to 1989-90 are tabulated in table No.10.7. It may be seen from table that the bauxite consumed in Alumina making for Export purpose has been shown separately from 1987. In 1975 the total consumption was of the order of 1.740 million tonnes which increased to about 4.487 million tonnes in 1989-90 showing an increase of 2.747 million tonnes and in terms of percentage is about 255 in 15 years. There has been marked increase in consumption from 1987 onwards and the highest consumption being reported in 1989-90. The industry-wise consumption and percentage during 1989-90 is given below :

TABLE 10.6 SPECIFICATIONS OF BAUXITE CONSUMED IN IMPORTANT IRON & STEEL INDUSTRY

Sl.No.	Name & Address of consumer	Purpose for which used	Specifications
1.	Bhilai Steel Plant Bhilai, Durg, M.P.	As a flux	Size - 55-100 mm Al_2O_3 - 55%
2.	Bokaro Steel Plant Bokaro Dhanbad, Bihar.	- do -	Gibbsite Size - 25-60 m Al_2O_3 - 50% SiO_2 - 8% (reactive) SiO_2 - 6% (non reactive)
3.	Durgapur Steel Plant Durgapur, Burdwan West Bengal.	- do -	Size - 50-100 mm Al_2O_3 - 50-54% Fe_2O_3 - 7-10% $TiO_2 + SiO_2$ - 12.5-13.5%

Source : Directory of Mineral Consumers in India
Vol. I, PP 97-99, IBM, Nagpur.

TABLE 10.7 : CONSUMPTION OF BAUXITE DURING 1975, 1980 & 1984 ONWARDS (BY INDUSTRIES)

(QUANTITY IN TONNES)

Sl.No.	INDUSTRIES	1975	1980	1984	1985	1986	1987(R)	1988(R)	1989-90(P)
	ALL INDUSTRIES	1,739,698 (100.00%)	1,292,856 (100.00%)	2,041,235 (100.00%)	2,035,142 (100.00%)	1,980,842 (100.00%)	2,132,200 (100.00%)	3,951,300 (100.00%)	4,487,000 (100.00%)
1.	Alluminium[1,2]	1,438,834(5) (82.70%)	1,050,071(6) (81.22%)	1,592,634(6) (78.02%)	1,592,926(6) (78.27%)	1,502,322(6) (75.84%)	1,622,000(7) (76.07%)	2,271,100(7) (57.48%)	2,532,400(7) (56.44%)
2.	Alumina (export)	N.A.	N.A.	N.A.	N.A.	N.A.	21,100(e) (0.98%)	1,201,100(e) (30.40%)	1,465,700(e) (32.66%)
3.	Refractory	78,398(16) (4.50%)	54,170(24) (4.18%)	219,633(31) (10.75%)	180,470(30) (8.86%)	186,429(31) (9.41%)	173,833(36) (8.15%)	180,700(36) (4.57%)	188,800(34) (4.20%)
4.	Cement[3]	96,225(12) (5.33%)	84,925(10) (6.56%)	106,175(14) (5.20%)	129,960(22) (6.38%)	161,550(23) (8.15%)	188,300(25) (8.83%)	174,400(26) (4.41%)	182,100(24) (4.06%)
5.	Abrasives	73,889(7) (4.24%)	39,643(7) (3.06%)	71,332(6) (3.49%)	75,341(8) (3.70%)	74,856(8) (3.77%)	78,100(8) (3.66%)	71,800(8) (1.81%)	65,600(8) (1.46%)
6.	Chemicals	29,548(14) (1.69%)	42,575(17) (3.29%)	22,788(12) (1.11%)	33,420(11) (1.64%)	35,743(11) (1.80%)	35,200(10) (1.65%)	34,800(9) (0.88%)	33,800(7) (0.75%)
7.	Iron & Steel	16,413(4) (0.94%)	15,026(5) (1.16%)	12,274(5) (0.60%)	10,475(5) (0.51%)	12,795(5) (0.64%)	11,084(5) (0.52%)	11,200(5) (0.28%)	12,300(5) (0.27%)
8.	Alloy Steel	647(5) (0.037%)	897(4) (0.069%)	8,969(5) (0.43%)	2,270(6) (0.11%)	135(5) (0.006%)	100(5) (0.004%)	100(5) (0.003%)	100(2) (++) (.002)
9.	Ceramics	5,704(9) (0.32%)	5,370(6) (0.41%)	5,380(7) (0.26%)	4,424(6) (0.21%)	3,259(8) (0.16%)	1,500(7) (0.07%)	1,800(7) (0.04%)	1,800(5) (0.04%)
10.	Charge Chrome/ Ferro alloys	-	-	2,019(2) (0.09%)	5,627(2) (0.26%)	3,536(2) (0.17%)	878(2) (0.04%)	4,200(2) (0.10%)	4,200(2) (0.09%)
11.	Others	40(1) (0.002%)	179(5) (0.013%)	31(1) (0.001%)	229(2) (0.011%)	217(2) (0.010%)	200(3) (0.009%)	200(2) (0.005%)	200(2) (++) (.004%)

Figures in parenthesis to the right denotes no. of units and figures in parenthesis below indicates the percentage of all Industries.

1. Consumption of BALCO is for the financial year. 2. Consumption excludes the Bauxite consumed in alumina which is exported.

3. Excludes consumption of laterite which was 329,409,392,700, 475,700 and 466,000, tonnes during 1986, 1987, 1988 and 1989-90 respectively.

SOURCE : ME Division, IBM, Nagpur.

Industry	Quantity in tonnes	Percentage
(a))Aluminium and Alumina	3,998,100	89.10
(b) Refractory	1,88,800	4.20
(c) Cement	1,82,100	4.06
(d) Abrasive	65,600	1.46
(e) Chemical, Iron & Steel Ceramics, Alloy steel etc.	52,400	1.18

Pattern of Consumption :

The table 10.7 further reveals that the bulk of the bauxite is consumed in metallurgical industry which accounts about 76 to 89 percent of the total consumption the remaining 11 to 24 percent is accounted by Refractory, Cement, Abrasive, Chemicals, Iron & Steel and other industries. Among these industries the major share is accounted by refractory and Cement industries.

10.3.1 METALLURGICAL INDUSTRY :

The year wise consumption of bauxite for the years 1985 to 1990 is given in table 10.8 in respect of 5 units. The major consumption is reported from NALCO and next in order is HINDALCO. The NALCO started consumption of bauxite from 1987 onwards[17].

The present consumption of aluminium in the country is of the order of 0.450 million tonnes per year. The per capita consumption in India is bare 0.5 kg. which is very much below compared to advanced countries, viz. USA 24 kg, Ja-pan 20 Kg; Hungary 17 Kg. This is not comparable even with that of other developing countries such as Brazil 3 Kg; Argentina 3 Kg ; Egypt 3 Kg. An increase of one kg per capita in India, would mean a total requirement of nearly a million tonnes per year.

TABLE 10.8 : CONSUMPTION OF BAUXITE IN ALUMINIUM INDUSTRY DURING 1985 TO 1990

(Quantity in tonnes)

Sl. No.	Name of the Unit	1985	1986	1987	1988	1989	1990
1.	BALCO Korba	549,604	541,806	526,021	513,275	510,680	522,235
2.	HINDALCO, Renukoot	752,778	738,417	744,921	971,246	N.A.	N.A.
3.	MALCO Mettur	57,349	55,357	47,104	72,525	N.A.	N.A.
4.	INDAL (Alupuram Belgaum & Muri) Total	233,195	166,742	175,670	491,130	469,610	473,841
5.	NALCO Damanjodi	N.A.	N.A.	128,244	1,823,221	2,261,052	1,866,874

A rough analysis of sectorwise consumption pattern of aluminium in India for the year 1988 are, electrical sector 40% ; Transport 17%, Household and other miscellaneous 17% ; machinery/equipment and other 10% and the remaining percentage is accounted in Building and packing sector[18,19].

10.3.2 CHEMICAL INDUSTRY

The unitwise consumption of bauxite in 6 important chemical industry during 1985-90 are given in table No.10.9. Among these units, M/s Dharamsi Morarji Chemicals unit at Ambarnath, Dist. Thana, and Kumhari Durg Dist. M.P. are reported to have consumed more than ten thousand tonnes per year.

10.3.3. REFRACTORY INDUSTRY

Table No.10.10 shows the unit wise consumption of bauxite in important refractory industry during 1985-90. M/s ACC refractory works, Mahavir industries, Orissa Industries Ltd., and M/s Natraj Ceramic are the important consumers of bauxite in their refractory works.

10.3.4 ABRASIVE INDUSTRY

Year wise, consumption of bauxite in 5 important abrasive units are tabulated in table No.10.11. Both the important units namely M/s Corborandum Universal Ltd. and M/s Orient Abrasive Ltd. are located in Gujarat.

10.3.5 CEMENT INDUSTRY

The Unit-wise consumption of bauxite/laterite in 11 important Cement Plants are given in table No.10.12. Some of the important consumer of bauxite are M/s Kesoram Cement, Orient Cement. and Panyam Cements. The remaining plants are mostly uses Laterite in their plants.

TABLE 10.9 : UNITWISE CONSUMPTION OF BAUXITE IN IMPORTANT CHEMICAL INDUSTRY DURING 1985 TO 1990

(Quantity in tonnes)

Sl. No.	Name of the Unit	1985	1986	1987	1988	1989	1990
1.	Bengal Chemical & Pharmaceutical Works Ltd., Calcutta, W.B.	2,400	1,838	2,400	1,303	766	1,220
2.	C.D. Thakkar & Co., Calcutta.	2,000	2,000	Lockout in Dec., 1986			
3.	Dharamsi Morarji Chemicals Ambarnath, Thana, M.S.	13,180	13,993	13,167	12,857	12,724	15,589
4.	Dharamsi Morarji Chemicals Kumhari, Durg, M.P.	11,726	11,047	10,984	12,157	N.A.	N.A.
5.	India Sulphacid Industry Ltd., Shahabad, Kuruksh-etra, Haryana	1,118	3,721	5,174	5,174[e]	N.A.	N.A.
6.	Phosphate Co. Ltd., Rishra Hooghly, W.B.	1,291	1,291	1,291	1,291[e]	N.A.	N.A.

SOURCE : M.E. Division, IBM, Nagpur.

TABLE NO.10.10 : UNITWISE CONSUMPTION OF BAUXITE IN IMPORTANT REFRACTORY INDUSTRY DURING 1985 TO 1990

(Quantity in Tonnes)

Sl.No.	Name of the Unit	1985	1986	1987	1988	1989	1990
1.	ACC Refractory Works, Katni, M.P.	39,108	38,080	37,741	38,004	N.A.	N.A.
2.	IPITATA Refractory, Dhenkanal, Orissa	865	4,279	6,732	4,473	3,684	3,437
3.	Mahavir Industries Ltd., Bhilwara, Rajasthan.	32,764	32,764	32,764	32,764[e]	N.A.	N.A.
4.	Orissa Cement, Refractory Unit, Sundargarh, Orissa.	11,270	19,982	12,770	1,458	2,518	2,972
5.	Orissa Industries Ltd., Rourkela, Latikata Works & Orissa Industrial Ltd., Rourkela, Barang, Orissa.	13,331	12,819	17,192	19,483	13,490	19,270
6.	Pratap Steel Ltd., (Refractory Division)	2,880	3,600	3,590	1,653	2,610	1,579
7.	Shri Natraj Ceramic Dalmiapuram, Tiruchirapalli	26,670	21,550	21,550	11,715	12,083	11,537
8.	Tata Refractories, P.O. Belpahar, Sambalpur, Orissa	N.A.	N.A.	8,088*	N.A.	N.A.	N.A.
9.	Valley Refractories Ltd., Chirkunda, Bihar	3,700	3,908	893	6,185	16,231	N.A.
10.	VRW Refractories Vanagram. Madras	6,112	6,322	10,800	5,321	5,251	6,028

* Financial Year

SOURCE : ME DIVISION, IBM, NAGPUR.

TABLE 10.11 : UNITWISE CONSUMPTION OF BAUXITE IN IMPORTANT ABRASIVE INDUSTRY DURING 1985 TO 1990

(Quantity in tonnes)

Sl.No.	Name of the Unit	1985	1986	1987	1988	1989	1990
1.	Carborandum Universal Ltd., Okha (Gujarat)	24,830	24,207	31,325	24,964	N.A.	N.A.
2.	Emery India Pvt. Ltd., Jamnagar, (Gujarat)	2,551	2,890	2,559	3,067	3,717	N.A.
3.	Indian Abrasives Faridabad, (Haryana)	900	700	715	750	790	900
4.	Orient Abrasives Ltd. Porbandar, Gujarat.	41,095	41,095	41,095	41,095[e]	N.A.	N.A.
5.	Royal Abrasives Shahpur, Gujarat	1,865	1,510	1,510	1,510[e]	N.A.	N.A.

SOURCE : ME DIVISION, IBM, Nagpur.

TABLE 10.12 : UNITWISE CONSUMPTION OF BAUXITE/LATERITE IN IMPORTANT CEMENT INDUSTRY DURING 1985 TO 1990

(Quantity in tonnes)

Sl.No.	Name of the Unit		1985	1986	1987	1988	1989	1990
1.	ACC, Kymore, Jabalpur M.P.	L	3984	39850	28090	29375	N.A.	N.A.
2.	ACC, Mancherial, Adilabad, A.P.	L	21550	19308	14741	10838	N.A.	N.A.
3.	Birla Cement, Chittorgarh, Rajasthan	B	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
		L	19901	19901	30218	33299		
4.	CCI, Nayagaon	B	490	80	Nil	Nil	N.A.	N.A.
		L	14565	14030	13195	14842	N.A.	N.A.
5.	CCI Tandur	L	Nil	1432	21335	19408	N.A.	N.A.
6.	Kesoram Cement Basant nagar, Kasimnagar, A.P.	B	33000	28000	24000	26000	N.A.	N.A.
		L	14000	18000	16000	16000	N.A.	N.A.
7.	Maihar Cement	L	27605	26825	19971	22434	N.A.	N.A.
8.	Orient Cement	B	7793	13212	15039	17041	17041	16497
	Devapur	L	19195	21921	13517	12853	N.A.	N.A.
9.	Panyam Cement Kurnool, A.P.	B	18589	19601	21188	14030	11040	21263
10.	Rajashree Cement	B	N.A.	N.A.	18813	26667	N.A.	N.A.
	Gulbarga, Karnataka	L	N.A.	N.A.	797	18	N.A.	N.A.
11.	Udaipur Cement	B	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Bajajnagar, Udaipur, Rajasthan	L	33845	33845	33845	33845[e]	N.A.	N.A.

NOTE : B - Bauxite L - Laterite

10.3.6 STEEL INDUSTRY

There are four Iron & Steel Plants which reported consumption of bauxite. The yearwise consumption during 1985-90 are given in table 10.13. Among the plants, M/s Durgapur Steel Plant and Bokaro Steel Plants are the important consumer and small quantity of bauxite is also consumed by IISCO, Burnpur.

TABLE 10.13 : UNITWISE CONSUMPTION OF BAUXITE IN IMPORTANT IRON & STEEL INDUSTRY DURING 1985 TO 1990

(Quantity in tonnes)

Sl.No.	Name of the Unit	1985	1986	1987	1988	1989	1990
1.	Bhilai Steel Plant Bhilai, Durg, M.P.	6,000	5,600	2,800	1,500	N.A.	N.A.
2.	B.S.L. Bokaro, Dhanbad, Bihar	971	1,897	2,513	3,000	4,053	5,379
3.	D.S.P. Durgapur, Burdwan, W.B.	2,960	4,803	5,434	5,310	N.A.	N.A.
4.	IISCO, Burnpur, Burdwan, W.B.	539	327	335	234	180	205

SOURCE : M.E. DIVISION, IBM, NAGPUR

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