CHAPTER-13

OUTLOOK, PROBLEMS AND PROSPECTS

13.1 INDIAN SCENARIO

The prospects for the Aluminium industry in India are quite bright. Indian aluminium industry has made rapid strides during the past two decades. The production of primary aluminium metal which was around 192,000 tonnes in 1979-80 has touched a level of 427,000 tonnes in 1989-90 showing an overall increase of 122 % over a decade. The future growth is expected to be not less than 8 % per annum and the consumption of aluminium is expected to reach a level of about one million tonnes by the turn of this country[1].

In the past, per capita consumption of aluminium in India was at a dismally low level and even today it is barely 0.5 Kg. as compared to the world average of 4 Kgs. In some of the developed countries it is quite high e.g. USA 24 Kg. Japan 20 Kg., Hungary 17 Kg. Electrical sector in India, alone consumes almost half of the domestic production. If this metal is made available easily there is possibility of increasing it's consumption in other sectors like transport, building, packaging, where there is great potential for it's use.

Now that the production of aluminium has increased considerably, the period of nineties is likely to witness a more balanced growth in use of aluminium in different sectors. The projections are that the metal consumption will go up at a rate of 8 % per annum compounded during the period 1990-95 and about 7.5 % in the next 5 years. With the active support of the Government, concerted efforts are being made by the industry to step up the production by installing new plants[3]

With the progressive commissioning of Aluminium plants in the country, India has started generating exportable surplus of Aluminium. During 1988-89, foreign exchange of about Rs. 273 crores was earned by the primary producers from exports of alumina, aluminium metal and semi fabricated products. During 1989-90, export earnings rose to Rs.410 crores, NALCO having lions share in the earnings[2].

Compared to other non-ferrous metals, India happens to be fortunate in the field of aluminium, mainly because of substantial reserves of metal grade bauxite. The potential was not really tapped fully, till the advent of National Aluminium Company Limited (NALCO). Earlier India was importing aluminium but after the commissioning of NALCO, the country is not only self-sufficient, in aluminium but there is surplus to export also. Today aluminium industry enjoys free-market economy. and Governmental control over distribution and pricing of primary aluminium has been dispensed with. The down stream industries also have been freed from licensing requirements. India has today three objectives in the Aluminium sector (a) Steping up the production (b) Promote domestic consumption (c) Export metal and down stream products on larger scale.

In India aluminium has to face serious competition from steel among metals and plastics among nonmetals. Plastic poses a major challenge in the packaging and transport sector, because of it's advantages of physical properties. But aluminium's relative advantages are it's assured indigenous availability and recylability. Therefore an intergrated approach is called for to identify new end-uses, according to it's technical superiority over it's substitutable meterials and related cost benefits. The sectors which have potential for application of aluminium are transport, packaging, aerospace, building and architecture, power transmission, furniture and fittings, automobiles, defence etc. Also suitable Government fiscal policies congenial to increasing the domestic consumption will be very much helpful to the growth of aluminium industry[2].

The working group for aluminium for the Eighth five year plan had made an exercise and recommended that the export effort should be at least 10% of the domestic demand. However, promotion of export is beset with challenges as a result of the changes which have taken place in the world aluminium industry during the last decade. Our aluminium industry has to compete with other countries in the prevailing scene, to make a place in the world market[3].

To be internationally competitive in the aluminium trade, the Indian companies will have to modernise their plants/equipments, use latest technology and improve quality. In this regard all the producing companies have taken positive action. Efforts are being made to make full use of present capacity and to instal new smelters to meet the future growing demand. The manufacturers of semi-fabs and products will also have to make similar efforts to modernise their plants, as well as their technology to compete in the international market.

Our strategy for the Nineties should be to attain a level of technology and expertise so as to optimise cost of production, achieve higher production, introduce new applications for use of aluminium and it's alloys with a view to increase the domestic consumption and also augment export of aluminium and it's products.(3)

13.2 ALUMINIUM CONSUMPTION

Aluminium is an important metal considered second only to steel in quantity and value produced. In India consumption of aluminium has increased by about 27 times since 1950 - 51 from 14800 tonnes to 400,000 tonnes in 1988-89, because of its merits for variety of applications.[1] Aluminium being a light metal with high strength to weight ratio can substitute many other conventional metals in vital areas like space-use, defence, buildings, and construction, transportation and domestic hard ware etc. A study of the increase in the consumption of various materials like lead, copper, aluminium, plastic, wood, steel and cement during the 20 years period 1960-1980, has revealed that in case of steel and cement it was 2-3 times increase, whereas in the case of aluminium and plastic, the increase was of the order of 30-40 times. This is on account of substitution of the conventional materials by aluminium/plastics. But still the percapita consumption of aluminium in India is only 0.5 Kg. It seems an uphill task to bring up the percapita consumption in this country even to the level, prevailing in developing countries like Brazil, Argentina and Egypt where the percapita consumption is 3 Kg.

In India the level of consumption is not only low, but pattern of use is also obsolete. In the world, pattern of consumption has shifted from the previously dominated utensil fabrication, electrical cables and transmission lines to transportation, packaging, building and architectural applications. But the bulk of the consumption (about 40%) in India is still in electrical sector only. The other important sectors for consumption i.e. transportation, packaging, building etc. are yet to be tapped in substantially[7].

The estimated demand for semi-fabricated products during the next four years starting from 1991-92 onwards is estimated to be 4.57, 4.94, 5.33 and 5.76 lakhs tonnes respectively. In the coming years the demand is anticipated to increase and as mentioned earlier it is presumed that domestic consumption will grow at the rate around 8 % during Eighth Plan period. In consonance with these demand projections, the three major producers NALCO, HINDALCO & BALCO have planned to expand their primary production capacity by 110 kt/y, 100 kt/y, and 50 kt/y respectively during the Eighth Plan period. The exercise made for demand, supply & enhanced smelting capacity during Eighth plan and beyond are given in Table 13.1[7].

TABLE 13.1 : DEMAND SUPPLY AND SMELTING CAPACITY

('000 tonnes)

Year	Demand	Supply	Smelting capacity
1990-91	463	488	610
1991-92	505	488	610
1992-93	550	488	610
1993-94	600	488	610
1994-95	654	488	610
1995-96	706	704	880
1996-97	763	704	880
1997-98	824	704	880
1998-99	890	704	880
2000 AD	961	904	1130

13.3 PROMOTION OF ALUMINIUM CONSUMPTION

The use and consumption of aluminium metal in India can be boosted by increasing the intensity of it's application in the sectors where potential for it's use exists and it has made progress to some extent in these sectors. The sectors where aluminium can play an important role and financial benefits that may accrue are as follows :-

(i) Transport sector : In the transport sector aluminium is a big saver of energy due to it's light weight. Aluminium metal could be used extensively for making bus/truck bodies, cartings and compo..ents in automobiles. It is understood the use of aluminium can conserve 2.8 m^3 of wood in the construction of a truck body[8].

According to the estimates made by the Gujarat State Road Transport Corporation, if aluminium is used in transport buses, the savings in HSD per bus/year is about 2375 litres. Studies conducted by the DGTD show that with a weight reduction of 20 % in cars, 15 % in buses and 10 % in trucks a net saving of Rs. 740 million in foreign exchange can be expected by way of reduced fuel consumption. The only passenger car in India which uses aluminium is Maruti using 20 Kg./car whereas the world average is 60 Kg. Aluminium and it's alloys are found suitable to replace several parts in the railway freight wagons and even some railway wagons have been built of aluminium[1].

(ii) Building and Architecture : Aluminium can be used for making doors, windows, frames, roofing sheets, artificial roofing and decorative tiles. The cost of making aluminium frames is considerably less as compared to teakwood. Therefore the use of aluminium in building constructions would effect savings in consumption of costly teak wood.

(iii) Electrical sector : All Aluminium alloy conductors (AAAC) has substituted the conventional ACSR conductor in the advanced countries. In India, this substitution is yet to take place.

(iv) Canning and packaging sector : Canning and packaging industry is the single largest consumer of aluminium in the developed countries like USA and UK. It's non-toxic characteristics, durability, thermal properties make it ideal for packaging and canning purpose. In India the use of aluminium in this sector is very marginal compared to advanced countries and there is ample scope for such applications.

(v) Cable wrap : In the telecommunication sector the requirement of aluminium for cable wrap is expected to be quite high.

(vi) New uses : Potential areas are beer cans, processed fish meat cans, regulators for LPG cylinders, replacement of brass forgings etc. The list is ever growing.

(vii) Defence sector : In the form of high strength aluminium alloys in making light weight military bridges, trackways, helipads, armour and armaments etc[8].

13.4 **DEMAND** : India has a large potential for growth of demand for aluminium. If we consider to bring up the per-capita consumption in this country even to the level pre-vailing in developing countries like Brazil, Argentina etc it will be a stupendous tank. We may plan initially for a modest percapita consumption of one kg. to start with.

There has been a significant shift in the pattern of consumption during the last 30-40 years. In 1950 household and commercial sector, which was the largest consumer of aluminium accounted for 52% of the total consumption, whereas in 1980 the electrical sector alone was the largest consumer sharing 52% of the consumption. As already mentioned earlier, there is vast potential for growth of demand in transportation sector, which is yet to be tapped. Other sectors where po-tential for demand exists are building and construction, defence, canning and packaging. For packaging industry we are presently importing substantive quantity of tin every year at a huge cost. If Aluminium could be made available at compe-tative prices, increasing demand from various sectors, are expected. Reasonable estimates of future demands are con-sidered essential, for planning commensurate production facilities and infrastructure requirements[9].

Demand Estimate VIII Plan[8]

The Planning Commission has projected 6% rate of growth of national economy during the Eighth Plan period resulting in an accelerated rate of growth of the industrial sector.

The sub-group has considered an average annual growth of demand for primary aluminium at 8 % during the period 1989-90 to

1994-95. While estimating the total demand, the sub-group has also made a provision for export of aluminium metal to the extent of 10% of the domestic demand to earn the valuable foreign Exchange. Domestic demand of EC and CG grade aluminium during 1990-95 upto 2004-05 AD are given in the following table 13.2.

TABLE 13.2 : DOMESTIC DEMAND FOR EC GRADE AND CG ALUMINIUM UPTO 2004 - 05 A.D

(In '000 t/yr)

Year	EC	CG metal	Total Aluminium: Domestic demand	Total Aluminium: Export provision	Total demand
1989-90	151 (38.5)	241 (61.5)	392	39	431
1990-91	161 (38.0)	262 (62.0)	423	42	465
1991-92	170 (37.3)	287 (62.7)	457	46	503
1992-93	181 (36.6)	313 (63.4)	494	49	543
1993-94	192 (36.0)	341 (64.0)	533	53	586
1994-95	204 (35.5)	372 (64.5)	576	58	634
Total 1990-91 to 1994-95)	908 (36.6)	1,575 (63.6)	2,483 (100)	248	2,731
1999-2000	269	558	827	83	970
2004-05	348 (300)	812 (72.0)	1,160 (100)	176	1,276

NOTE: 1. Figure in the paranthesis indicates percentage share of EC grade and C.G. metal in total domestic demand for aluminium.

2. Estimates made when Eighth Plan was to start from 1990-91.

The Sub-group has also made an estimation of the anticipated availability gaps/surplus of aluminium metal during 1990-95, which is given in following table No: 13.3.

TABLE 13.3 : PROJECTED DEMAND ANTICIPATED AVAILABILITY GAPS AND SURPLUS OF ALUMINIUM METAL DURING 1990-95

(in '000 tonnes/year)

Year	Projected domestic demand	Anticipated availability	Resultant gap (-) surplus (+)
1990-91	423	483	(+) 60
1991-92	457	503	(*) 46
1992-93	494	503	(+) 9
1993-94	533	540	(*) 7
1994-95	576	550	(-) 26

It may be seen that during the first two years **1990-91 and 1991 - 92,** the supply of aluminium is in excess of the domestic demand to the extent of 60,000 and 46,000 tonnes respectively, which could be exported. However, for 1992-93 & 1993-94 the gaps between domestic demand and supply is not much. It is only to the tune of 9000 to 7000 tonnes.

During 1994-95 the demand may exceed the supply by about 26,000 tonnes. Therefore, beyond 1994-95, in the absence of fresh capacities for production, the deficit in supply may further widen during the ninth Five Year Plan[8].

13.5 ALUMINIUM PRODUCTION CAPACITY AND PROPOSED EXPANSIONS

The Aluminium production capacity of the producing companies in India is given below[7] :-

Company	Installed Capacity in tonnes	Production /year during 1990
Public sector		
BALCO	100,000	89,319
NALCO	218,000	141,705
Private sector		
HINDALCO	150,000	135,039
INDAL	117,000	
NALCO	25,000	64,912
TOTAL	610,000	430,975

To meet the increasing demand after 1994-95 and in Ninth plan the production capacity in the following three companies is planned to be augmented as given below :-

Company	EXPANSION UNDER CONSIDERATION (TONNE)	TOTAL CAPACITY AFTER EXPANSION (TONNES)
BALCO	50,000	1,50,000
HINDALCO	1,00,000	2,50,000
NALCO	1,10,000	3,28,000

Finally the total picture envisaged is as follows :-

Name of company	Existing capacity	Planned expansion	Capacity after expansion (Tonnes)
BALCO	100,000	50,000	1,50,000
HINDALCO	150,000	100,000	2,50,000
INDAL	117,000	-	1,17,000
MALCO	25,000	-	25,000
NALCO	218,000	110,000	3,28,000
	610,000	260,000	8,70,000
Green field Aluminium smelter	-	-	3,60,000
		TOTAL	1,230,000

The sub-group has suggested that the actions for expansions should be initiated now only, keeping in view the gestation period which normally extends to 3-4 years.

Production capacity of the existing smelters is now under utilised for lack of power supply. Therefore adequate power should be made available to these smelters to produce metal as per their installed capacity.

13.6 INPUTS FOR PRODUCTION OF ALUMINIUM

The major inputs for the production of aluminium metal are bauxite, power, caustic soda, calcined petroleum coke, pitch, cathode carbon material, cryolite, aluminium fluoride, fuel oil and coal. The investment costs in India are comparable with the investment costs elsewhere in the world, but the production cost is very high. Cost of production is largely determined by the cost of major inputs like power, coke, pitch, caustic soda. The consumption of inputs for one tonne of aluminium is as given below[2] :-

Inputs	Consumption Norm (t)
Bauxite	6.0
Power	17,500 kwh
Caustic soda	0.180
Calcined petroleum	0.400
Pitch	0.150
Cathode carbon material	0.025-0.35
Cryolite	0.010
Aluminium fluoride	0.030
Fuel oil	0.250-0.800
Coal	1.8 -3.0

It may be seen from the table that for one tonne of aluminium about 9 tonnes of input material and 17,500 kwh of power is required. Power is a very crucial input for the conversion of alumina to aluminium and it constitutes about 40 % of the production cost. In view of the importance of this metal to various industries the aluminium industry in many countries gets power at somewhat concessional rates. On the contrary there is no such concession given for the rates of power supply in India and further the power supply is inadequate and erratic.

Next to power, the most important input for aluminium is calcined petroleum coke (CP COKE), accounting for about 12% of the cost of production. During the last decade the price of CP coke has increased by 154 % in India whereas in the international market the increase is about 94%. Indigenous production being less, it has to be imported and high rates of import levies are to be paid.

Coal Tar Pitch (CTP) is supplied mainly by SAIL. Price of CTP has increased substantially during the last decade from Rs. 1131 in 1979 to 4900 per tonne in 1986. Cost of CTP constitutes about 4 % of the Cost of production of aluminium.

Caustic soda another input accounts around 5% of the cost of production. In the international market it's price has decreased, while in India it has increased by 138 % from Rs.2685/t in 1979 to Rs. 6200/t in 1986.

Raw materials required for the production of one tonne of aluminium costs around Rs.13222/t and other operating costs are about Rs. 2567/t.

Specific Consumption of Raw materials and Power

Specific consumption of raw materials and power, per tonne of alumina and aluminium production in Indian plants are given in Table No: 13.4. The consumption of power at NALCO is the lowest among all the plants.

13.7 EXPORT PROSPECTS

India so far mainly was interested to meet the demands of domestic market. But now considering the huge proved bauxite reserves, India is in a position to produce surplus and also export. Other than exporting the metal, India can export down-stream fabricated products to the world market. India's contribution in this field to the world market is however neglible for the present. It may be stated here that a sizeable portion of the global trade in aluminium takes place in the economic regions with which India is placed geographically in an advantageous position. These regions are :-

1. SAARC countries
2. South east & far east.
3. West Asian countries.
4. African countries.
5. Western countries.

The major scope for exports of semis lies in rolled products, foils, cables, conductors, utensils, extrusions, forging and castings For the manufacture of these products modern equipments are required to produce quality products.

In order to improve exports on long term basis the industry could consider investments in installing modern equipments to manufacture the semis of the standard which should compete in the world market in terms of quality and cost.

Government may also consider schemes of incentives to give encouragement to aluminium exporters(8).

India has got distinctive competence in the semi-fabricated products. India foils, HINDALCO and INDAL have already exported their products to the international market to the tune of 2.5 mt. Therefore planning may be done for significant supply of semi-fabricated products on long term basis.

TABLE No: 13.4 : SPECIFIC CONSUMPTION OF RAW MATERIALS & POWER DURING 1988 - 89

Specific Consumption	BALCO Korba (MP)	NALCO Damanjodi (Orissa)	HINDALCO Renukoot (U.P)	INDAL Belgaum (Karnataka)	MALCO Mettur (Tamil Nadu)
1	2	3	4	5	5
1. Average Plant Feed grade of Bauxite					
Al_2O_3 %	47-49	42-46	47-52	48-52	46-49
SiO_2 %	3-4	1.5-2.5	2-3.5	2-4	2-4.5
Fe_2O_3 %	16-20	20-30	10-18	15-18	20-23
TiO_2 %	7.5-8.5	2-3	7-10	5-7	1.5
LOI %	20-24	20-30	20-25	25-27	22-23
2. Per tonne of Alumina					
Bauxite (T)	2.770	2.980	2.903	3.04	2.760
Caustic Soda (T)	0.121	0.063	0.083	0.130	0.083
Lime (T)	-	0.028	0.256	-	0.268 (Burnt)
Steam (T)	3.670	-	4.887	-	-
Fuel Oil (Lit.)	116.040	-	86	-	-
Coal (T)	-	0.700	-	-	-
Bran (T)	-	0.004	-	-	-
Power (Kwh)	-	401	471	-	42

Contd. table 13.4

1	2	3	4	5	6
3. Per Tonne of Aluminium					
Alumina (T)	1.98 (Calcined)	1.990	2.120	1.910	1.940
Cryolite (T)	0.037	-	-	0.020	-
Fluoride (T)	0.048	-	-	0.033	0.038
Anode Paste (T)	0.569	-	-	-	0.593
C P Coke (T)	-	0.454	0.366	-	-
Hard/C T Pitch (T)	-	0.105	0.153	-	-
AC Power (Kwh)	17,116	15,464	16,495	16,310 (DC)	18,356

SOURCE : Handbook of Non-ferrous Metals 1990 (Aluminium, Copper, Lead & Zinc) pp 73-81, IBM, Nagpur.

The export of aluminium was between 2000 to 4000 tonnes during the period 1980-81 to 1987-88. During 1988-89 the export increased to 27,000 tonnes, which was solely from NALCO. In fact it is only after establishment of NALCO that India could generate surplus aluminium for export.[1] In 1990-91 the revenue generated through export was around Rs. 359 crores.

13.8 STATUS OF ALUMINIUM TECHNOLOGY AND NEED FOR FUTURE

The technology for the production of aluminium for the existing plants in India has been imported from different countries, as given below :-

PLANT	TECHNOLOGY IMPORTED
HINDALCO	KAISER-USA
BALCO	VAMI-USSR
INDAL	ALCAN-CANADA
MALCO	MONTECATINI-ITALY
NALCO	ALUMINIUM PECHINEY-FRANCE

There is a pressing need for assimilation and adoption of the available technologies so that substantial part of planning and designing of future alumina and aluminium plants could be taken up with indigenous knowhow. This can lead to substantial savings in payments to the foreign companies and more important to achieve self-reliance[4].

Comprehensive studies need be carried out, of the developments and changes taking place in bauxite exploration and mining, alumina refining, aluminium smelting, casting, rolling and extrusion etc., with a view to it's adoption in our conditions in order to :-

a) reduce energy consumption and raw material input

b) achieve higher productivity and efficiency of men and materials and

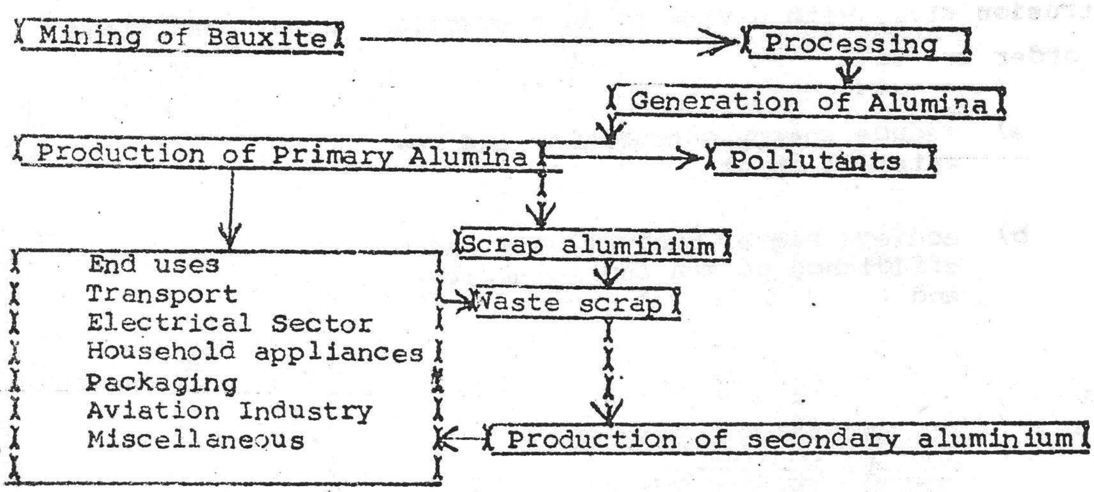
c) produce the metal alloys and semis of standards acceptable in the world market. Though R & D work done by the industry is quite impressive, it is desirable that aluminium producing companies should strengthen their R & D facilities in the following areas:

i) Bauxite mining
ii) Bauxite processing and alumina production
iii) Smelter and carbon technology and
iv) Alloy development, casting and fabrication technology including development of new applications.

With the establishment of Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDC) and Non-ferrous Alloys Technology Development Centre (NFTDC) by Govt. of India it would be possible now to give the much needed boost to R & D activity of aluminium industry in the country[8].

13.9 MANAGEMENT OF MATERIAL CYCLE

The production of aluminium starts from mining of Bauxite, processing, production of alumina and then smelting of alumina to produce primary aluminium. Aluminium is utilised for various applications and after a useful period rejected as waste-scrap, which can be reprocessed for making primary aluminium. In India however the recycling of waste scrap is not organised properly. The entire material cycle shematically is as follows[1]:-



Figu. 13.1 : MATERIAL CYCLE OF ALUMINIUM

13.10 COST OF PRODUCTION

(a) Bauxite

The present bauxite reserves in India are estimated to be 2.5 billion tonnes, account for about 10% of the world reserves. As compared to the resource available the rate of exploitation is quite meagre, which is only 4.8 million tonnes/annum as compared to 38.8 million tonnes in Australia and 14.2 million tonnes in Guinea. Another dishearting situation is that the Alumina plants in central India, which require only good quality bauxite are starved of this raw material because of the depletion of high grade ore in the captive mines and only the marginal grade ore is left insitu. It is necessary to bring improvement in bauxite processing technology particularly in the old plants so that these plants could accept marginal grade ore, and thus avoid cost involved for the good ore, which has to be transported over long distances .

The cost of bauxite production in India however appear to be comparable to leading producers of the world as may be seen in table 13.5.

TABLE 13.5 : COST OF PRODUCTION OF BAUXITE IN 1989

Country	Cost of Production	Country	Cost of Production
India	$ 13-15/t	Greece	$ 24-25/t
Australia	$ 10-11/t	Guinea	$ 34-35/t
Brazil	$ 9-10/t	Jamaica	$ 32-33/t
France	$ 19-20/t	World Average.	$ 22-24/t

India has potential to enter into the world bauxite market mainly based on the eastcoast deposits, having large thickness of bauxite zone, good quality ore with low level of contaminants which make them comparable to the best bauxite deposits in the world. In quality, Indian bauxite is comparable and even better than the Austalian ore. In Asian region, Japan and Soviet Union are known to be the biggest consumers and they are purchasing bauxite mainly from Australia & Guinea. India can also enter into the fray by supplying bauxite to these countries at competitive prices.

(b) Alumina

Alumina refining costs differ primarily due to variations in bauxite quality and recoverable alumina in the ore. Cost of production of alumina in some countries is given in Table No.13.6. Brazil has the lowest production cost, mainly due to low cost of labour, energy and transportation of bauxite from mine to refinery. **West Germany has the highest cost of production.**

In India production cost is higher, mainly due to high energy cost, high energy consumption and higher consumption of various inputs in Indian alumina plants.

TABLE 13.6 : COST OF PRODUCTION OF ALUMINA (1989)

COUNTRY	COST $ PER TONNE.
Australia	158-160
Brazil	150-160
India	270-280
Jamaica	210-220
USA	170-180
W.Germany	330-340
World Average	210-220

In spite of high energy price in India there is possibility of producing alumina at lesser cost after modernisation of old plants and by adopting energy efficient technology for new plants. Domestic demand for alumina being limited it appears more emphasis can be given for export. Keeping in view the ambitious aluminium smelter expansion plans of gulf area there could be vast scope for alumina export and India being nearer to gulf, can become a leading exorter. The long term supply contracts by India with Gulf states can be considered for boosting production of alumina and it's export.

(c) Aluminium

The production of aluminium is highly power intensive. The cost per tonne of Aluminium Production and energy cost per tonne in India and of some selected countries is given in table 13.7 & 13.8. Differences in smelter operating cost from country to country are primarily due to variations in energy costs and alumina costs. Though the production cost of aluminium in India is comparable to some European countries as may be seen from table No.13.7, but still it is considerably high compared to top ranking countries such as Brazil, Australia, and Norway as well as the world average. This is mainly due to the comparatively very high cost of energy in India. In table 13.8 energy cost per tonne of Aluminium in some of the selected countries is given. It may be seen that the energy cost in India is the highest.

TABLE 13.7 : COST OF PRODUCTION OF ALUMINIUM - 1989

Country	Cost US ($ per tonne)
Australia	1400
Brazil	1600
Canada	1400 - 1500
France	2000 - 2100
India	2100 - 2200
Italy	2100 - 2200
Norway	1700 - 1800
Spain	2000 - 2100
Switzerland	1800 - 2000
U.K.	2000 - 2200
U.S.A.	1400 - 1600
Germany	2200 - 2400
World Average	1400 - 1600

TABLE 13.8 : ENERGY COST PER TONNE OF ALUMINIUM PRODUCTION.

Country	Energy cost US ($ per tonne)
Australia	392.9
Brazil	343.7
Canada	138.5
France	295.2
India	595.3
Italy	436.7

Norway	229.1
Spain	495.7
Switzerland	267.2
U.K.	270.6
U.S.A	436.1
Germany	345.3
World average	300 - 400

With high electricity cost and more energy consumption in old operational cells, the smelting process in India is more expensive than most of the countries of the world. Under such circumstances, it is reported that the countries like USA & Japan have taken decisions to close their smelters, which were uneconomic for continuing the operation. The situation in India of course can be improved by efforts on minimisation of specific energy consumption of operational cells and search for cheaper energy resources.

13.11 RECYCLING OF ALUMINIUM AND UTILISATION OF SCRAP

Recycled aluminium is commonly known as secondary aluminium. Recycling of aluminium needs to be given due importance and attention, in order to conserve energy and reduction in energy cost. Conversion of aluminium scrap to metal needs only 5 % of power required for the conversion of bauxite to metal and also 5% of investments required for primary smelting. Production of secondary aluminium is also very much desirable from the point of view of environment protection. In case of production of Primary aluminium, huge quantity of hazardous gases are emitted in the atmosphere requiring stringent safe guards and necessitating considerable additional investments for pollution control measures.

Recycling is now a cost-effective, Technology intensive, sophisticated industry producing high quality metal for industrial use. Presently there is a large international aluminium scrap market and it can be attractive to import aluminium scrap (amounting to importing of electrical energy) and converting it to high quality metal.

Recycling of aluminium has achieved maximum importance in USA, West Germany, Japan and Italy. In some of the developed countries the share of secondary aluminium is as high as 32 % of the total production. It is estimated that 20% of world supply of aluminium metal will come from secondary aluminium by the year 2000 A.D.

Recycling of aluminium in India is still at very low level, and comparatively very small quantities are produced as secondary aluminium. Data regarding production of secondary aluminium is also lacking. Endeavour at national level is required, to increase the production and usage of secondary aluminium considering the shortage and high cost of electrical energy and the increasing cost of inputs for the production of primary aluminium. It is necessary to initiate organised action for systematic collection and utilisation of aluminium scrap in India. With the tremendous growth potential in the automotive, packaging and construction industries as well as consumer durables the recycling of aluminium is very essential and would be a profitable venture for a developing country like India[5].

13.12 RESEARCH ON RED MUD UTILISATION

To produce one tonne of metal 4.5 to 5.0 tonnes of bauxite ore has to be treated by Bayer's process. On caustic digestion bauxite leaves behind about 50% of it's own weight of an insoluble residue which is known as Red mud. It is estimated that annually about 45 million tonnes and 2 million tonnes of red mud are generated in the world and India respectively. Disposal of such large quantities of solid waste by their impoundment in mud lakes/ponds, causes problems of increasing land cost, storage and pollution.

R & D works have been carried out by the laboratories in India on the use and disposal of red mud. Brief details are given below :

CECRI, Karaikudi has been conducting investigations for the last two decades, on the possible use of red mud and it's acid washed derivatives as a material for pigments, paints, or corrosion resistant primers.

CGCRI, Calcutta has evolved methods for conversion of red mud and fly ash into sanitary ware and pottery etc. The CBRI, Roorkee claims to have developed the technology for production of red mud clay bricks.

The redmud disposed off by plants in Central India contains 18-20 % TiO_2. The possibilities of recovery of Titania have been examined by a two stage leach process.

Experiments have demonstrated that it is possible to strengthen portland cement, cement mortars and concretes by addition of 10% red mud in the mix, hence conservation of cement could be achieved to some extent by the use of redmud[6].

13.13 R & D ACTIVITIES IN INDIA

The major thrust areas for research and development activities for the Indian aluminium industry are:

i) Energy conservation.

ii) Cost reduction by optimising input consumption

iii) Production of value added items for alumina and aluminium[7].

In this regard R & D efforts carried out/being carried out by different producing companies and National Laboratories are given below in brief :-

BALCO :

At BALCO the major efforts under R & D are on problems upto the alumina production stage, energy conservation and development of specialised products. A pilot plant for the Technical evaluation of bauxite samples has been set up. As a result of research, rotary kilns have been modified which have shown reduction in fuel oil consumption by 24%, increase in production capacity by 60% and reduction in electric power by 30%. Efforts are being made for improving smelter parameters, improvement in cell design and mechanisation of cell operation through computerisation etc.

Balco has set up an alloy development and application centre, and also sophisticated analytical and testing facilities. Balco has been able to develop critical alloys which have been used in the country's prestigeous missile projects viz. Prithvi and Agni, for making Air to ground rocket, drilling rig, in set Antenna, artificial limb, special bus bars, shell casing for defence etc[1].

INDAL :

R & D work at Indal is mainly on conservation of rew materials, energy and development of new products and processes to ensure quality and economy to the endusers. Cryolite is being recovered from scrap pot lining. Carbon is also recovered from pot lining material to substitute imported anthracite.

In the field of new products Indal is developing some alloys for defence and air crafts, aluminium bodies for dumpers, trucks and even bullock carts.

NALCO

Nalco has been successful in introducing computerised voltage control system, and there by has achieved a substantial reduction in energy consumption. The consumption of power by Nalco is 15464 kwh/t which is much lower than the world average of 16250 kwh/t.[1]

Nalco is conducting laboratory work on development of special grade calcined alumina and microfined alumina. Experiments have been carried out on utilising red mud in the manufacture of paint and corrugated sheet cladding. Another important venture of NALCO is extraction and refining of gallium from redmud. a metal much needed by the fast growing electronics industry.

NALCO has drawn up plans to carry out pilot plant tests in the USSR to produce aluminium silicon alloys using Indian raw materials.

Plants and machinery are being procured for the development of special aluminium alloys for he automative industry.[10]

HINDALCO

R & D activities at HINDALCO are mainly aimed at energy conservation in their alumina refinery, Carbon plant and smelter, modifications of pots and development of new alloys. One of the achievement is replacement of rotary kilns by a modern gas suspension calciner thereby bringing down the consumption of fuel oil from 130 to 78 lit/tonne of alumina, which is comparable to the best figures in the developed countries.

HINDALCO has developed special high strength alloys, plates, and extrusions for defence applications[1].

MALCO

The company has installed a gallium recovery plant, a system for nuetralisation of red mud by the hydrochloric acid before it's disposal and is planning to install computer control in electrolysis with a view to reduce energy consumption[1].

Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC)

JNARDDC is setting up a modern R & D Laboratory at Nagpur to undertake full Techno-economic evaluation of bauxite for metal production. There is plan to set up a modern pilot plant for complete technological testing of bauxite for industrial Alumina production. It is in the process of developing computer software to estimate the processing value of each bauxite type under various technological conditions. This facilitates to establish the value of each type of Bauxite for alumina production and optimize the mining and supply to the plant.

The Centre would have capabilities for (i) assimilation and adaptation of technologies existing in the country and development of know-how and basic engineering packages, (ii) providing recommendations and analytical services to industries undertaking research programme towards reduction of energy, consumption of materials and new prospective processes, (iii) setting up and operation of data bank with all the available information on latest developments and (iv) providing training to engineers employed in the aluminium industries through organisation of workshops, group training programmes and individual fellowship training.

The establishment of entire infrastructure to provide all these facilities is expected to be completed in another four years time[11].

A wide range of equipments and analytical facilities are being installed in JNARDDC for bauxite testing and evaluation.

MAJOR EQUIPMENTS AND ANALYTICAL FACILITIES AVAILABLE IN JNARDDC FOR BAUXITE CHARACTERISATION & TECHNOLOGICAL TESTING

S.N.	Characteristic/ Test	Major Equipments and analytical facilities available in JNARDDC
1.	**Physical**	Multivolume pycnometer, Sieve analyser, Laser particle sizer, Specific surface area analyser, Multivolume pore size analyser, Angle of repose instrument, Polarising microscope, Scanning electron microscope.
2.	**Mechanical**	Roll crusher, Colloid Mill, Bond index ball mill, Air jet sieve, Wet screen set, Vibrating screens.
3.	**Chemical**	X-ray Fluorescence Spectrometer, Atomic absorption spectrophotometer, UV/VIS Spectrophotometer, Optical Emission Spectrometer, FT-Infra-red spectrometer, Gas chromatograph.
4.	**Mineralogical**	X-ray Diffractometer, FT-IR Spectrometer, Scanning electron microscope.
5.	**Technological**	Autoclaves, Thermometric Titrator, Lab Precipitator cum desilicator, Gamma ray settler
6.	**Computer facilities**	Main Frame computer - 4 M Byte Personal computers.

R & D WORK IN CSIR LABORATORIES

National Metallurgical Laboratory (NML), Jamshedpur

NML is doing research on the evaluation of Indian Bauxite for production of alumina, development of special aluminium alloys for electrical industry, construction application, production of synthetic cryolite and use of alumina for protective coating on steel.

Central Electro Chemical Research Institute (CECRI) Karaikudi.

CECRI is conducting research on (i) the development of protective coatings of aluminium (ii) use of aluminium as anodes in batteries (iii) Production of aluminium lithoplates and aluminium capacitors, development of special alloys for electrical industry (iv) production of synthetic cryolite from the waste flue of superphosphate industry.

RRL BHUBANESHWAR AND BHOPAL

Studies have been carried out to obtain aluminium from aluminium trichloride by fused salt electrolysis. It has undertaken studies to recover metal from red mud.

RRL Bhopal is conducting studies to reduce energy consumption in aluminium production, use of aluminium in transportation, aluminium equipment to tap solar energy, and to produce aluminium silicon alloys directly from bauxite.[(1)]

NON FERROUS TECHNOLOGY DEVELOPMENT CENTRE (NFTDC)-HYDERABAD

The newly set up NFTDC has conducted certain preliminary tests at DMRL Hyderabad on NALCOs high purity aluminium, to know it's suitability for producing aluminium-lithium alloys. As the results were found encouraging, NFTDC have proposed to set up a pilot plant for development of aluminium lithium alloys using NALCOs aluminium metal. These alloys are proposed to be used for meeting country's defence and strategic needs.[13]

ACID PROCESS FOR THE EXTRACTION OF ALUMINIUM FROM ARGENTINE WEATHERED BASALTS

Alternative methods to the Bayer's process have been developed in the countries lacking bauxite deposits. An acid process is proposed for the recovery of alumina, over 98.6% purity from the aluminous red soils of Argentina. Iron is present as colloidal hematite covering the surface of the aluminous minerals. Taking advantage of this characteristic tests were performed to obtain selective dissolution of iron and aluminium. Purification of the solution was carried out by solvent extraction and then the hydrated aluminium chloride was precipitated by bubbling hydrogen chloride gas. Finally the crystallised salt was thermally decomposed to obtain alumina having low iron and titanium contents.[17]

13.14 ALUMINIUM ALLOYS

A number of alloys have been developed to improve properties and performance of aluminium. These are :

1. Super Plastic Aluminium Alloys
2. Ultralight Aluminium Alloys
3. Powder metallurgy Alloys,
4. Aluminium matrix composites.

After the 2nd World War the new Al - Cu alloys, AA 2219 was developed with 6.3% Cu, which provides necessary strength as well as good weldability, superior resistance to stress, corrosion and higher elevated temperature properties. This alloy is being developed at BALCO.

Al - Zn - Mg alloy extrusions are finding more and more applications in our country to meet the general and strategic needs for sophisticated use, which call for combination of strength ductility and corrossion resistance. It is likely that several variations of this alloy series will be used for manufacture of bridges, power line towers, car bumpers, automobile wheel rims, lamp posts, tennis rackets etc. At the Korba Plant of BALCO, development of technology for commercial production of medium and high strength AL - Zn - Mg alloy extrusions is under way.

Special High strength alloys have been developed by HINDALCO.

NALCO has taken up collaborative R & D work on Aluminium Silicon Alloys in association with VAMI of erstwhile USSR with the assistance of UNDP. On successful completion of a Pilot Plant test, it has proposed to set up a demonstration unit of 30,000 tpy capacity at Angul with UNDP assistance

13.15 RECOVERY OF METAL VALUES :

Gallium

World production of Gallium is of the order of 35 million tonnes, Bulk of the world-gallium output comes as a by product from Aluminium output. Gallium is a rare metal, which passes into the Bayer's liquor.

The Central Electro Chemical Research Institute at Karaikudi has established a pilot plant at MALCO for recovery of Gallium, 100 gms per day from Bayer's liquor. The Galia (Ga_2O_3) content in Bayer liquor was reported to be 0.14 gm/litre.[12]

NALCO has proposed a collaborative R & D venture for the extraction and refining of gallium with the assistance of UNDP. The gallium content in NALCO's bauxite being appreciably high, it is proposed to set up an on-line demonstration unit for the extraction of two tonnes per year of crude gallium in the Alumina refinery at Damanjodi and to refine it to 6 N level through modern technology. The proposal has been submitted to the Government of India for getting UNDP assistance.[13]

Vanadium

Indian Bauxite deposits particularly those derived from traps contain 200-700 ppm of Vanadium. Important vanadium bearing bauxite deposits are :

- Amarkantak, M.P. (0.14 % V_2O_5)
- Rungarwadia, M.S. (0.04 % V_2O_5)

Bauxite of East coast contain 70-200 ppm of V_2O_5 in Orissa and 90-730 ppm in A.P.

In the process of conversion of Bauxite to Alumina, part of V_2O_5 goes into the Red Mud. Alumina plants in India are recovering vanadium salts, reported capacity being as under[12] :

BALCO	-	1200 tpy.
HINDALCO	-	800 - 1200 tpy
INDAL	-	1200 tpy each at Moorie and Belgaum.

13.16 PROBLEMS OF BAUXITE MINING :

In Bihar the land where mining leases have been granted belongs to parties other than lessees, there by lessees are not in a position to exploit the mineral freely.

In Tamilnadu Bauxite deposits are located in rubber and coffee estates. Therefore mining of the mineral in such area is not so easy.

In Gujarat the problems are different. The deposits are pockety and extremely irregular in shape. No detailed exploration work has been done, and the resources can be categorised only as possible reserves. As there is good demand for high grade ore, manual mines produce only high grade lumps, and the rest is dumped as waste.

Besides mining there are legislative and statutory problems also. One of the conditions for granting and renewing of bauxite leases in Gujarat state particularly in Jamnagar district, is that the lessee should set up an industry in Gujarat, based on the bauxite mined. The state government has also restricted the sale and transportation of bauxite out of state. This has rather resulted as detrimental to the bauxite mining industry. The government also insists that 60% of the mined bauxite should be earmarked for captive consumption. The permission for despatching the balance 40% out side the state is not granted speedily thus creating problems of accumulation of various grades of bauxite at the mine and their subsequent grade dilution and loss.

There is a good demand of specific high grade bauxite. This has resulted in selective mining of high grade ore. During this process considerable quantities of low grade bauxite ore is generated for which there is no local market. Therefore necessary legislative measures as well as technology to make use of such low grade material will have to be evolved if the bauxite resources available in the area are to be developed and utilised.

As no systematic exploration has been done in many of the bauxite bearing areas in the state, unsystematic mining practice is prevailing, with the result the environment in these mining areas has been adversely affected. There is no practice of reclaiming the mined out lands and restoration of the top soil and planting of trees on the dumps. These aspects need consideration and suitable steps will have to be taken by the concerned.[16]

13.17 NEW PROJECT PROPOSALS

Following are some of the new projects coming up in India:-

Pennar Aluminium Company, Maharashtra

Pennar Aluminium Company (PALCO) proposes to set up a plant for manufacturing sophisticated aluminium products including strips, sheets, wires and alloys for catering to power sector, transportation, food processing, construction, engineering and defence. The Prime Minister of India has laid down the foundation stone for this project at Mouda near Nagpur on March 7, 1992.

PALCO is expected to have a capacity of 24,000 TPA aluminium strips and sheets, 6000 TPA aluminium alloy conductors and 3000 TPA aluminium alloys. PALCO has made an agreement with NALCO for the supply of raw material. It has entered into technical collaboration with Pechiney of France, who will provide technical know how and assistance for the project[14].

Bauxite Calcination Plant in Gujarat

GMDC has taken decision to set up a bauxite calcination plant using high grade bauxite of Kutch at a cost of Rs.8.25 crores, having a capacity of 50,000 TPA at Gadhshisha village in Kutch district.[14]

Alumina Refinery at Visakhapatnam

Essar Group, L & T and Sanghi Group are reported to have tendered for the construction of one million TPA alumina refinery at Visakhapatnam, which is proposed to be export-oriented. The Far-East is expected to be the targetted main export area.

Bauxite Mine and Aluminium Smelter in Andhra Pradesh

An export oriented bauxite mine at Jerela in A.P. with a capacity of 2.30 million tonnes per annum is under planning. The Working Group of Planning Commission on aluminium has suggested that a new aluminium smelter with a capacity of 300,000 TPA could be set up in A.P. and the power for the smelter could be made available from the Godavari Gas Reserves.

Bauxite Mines in M.P.

New bauxite mines are under planning to mine the deposits of Mainpat and Sarguja in Madhya Pradesh to meet the demands of BALCO and HINDALCO smelters. The Projects are expected to come up soon as the reserves in the existing mines of BALCO and HINDALCO are exhausted.[14]

13.18 STRATEGIES FOR FUTURE

Almost three quarter of world's bauxite reserves are located in developing countries notably Guinea (5,600 MT), Brazil (2,250 MT), Jamaica (2000 MT), India (3037 MT), Guyana (900 MT), and Suriname (575 MT). Australia alone accounts for nearly 20 % of the world reserves. The European reserves (Hungary, Spain, France, etc.), though of high (456%) alumina content are predominently of monohydrate variety. The Australian Bauxite consists of Gibbsite and Boehmite, has high percentage of non-reactive silica. In Asia, other known commercial reserves are in Indonesia, Malayesia and Vietnam.

Indian proven bauxite reserves are also substantial and major deposits located on the East Coast are primarily gibbsitic with low level of silica (2.5%) making them highly amenable to economic production of alumina. Location of these deposits close to ore handling port of Visakhapatnam is also of added advantage as export of bauxite in bulk can be a viable proposition.

In view of potential for further development of aluminium industry in India, following areas are identified for consideration

(i) Compared to other non ferrous metals India is more advantageously placed in the field of aluminium mainly because of substantial reserves of metal grade bauxite. The Aluminium Industry is today placed in a regime of free market economy and years of governmental control over distribution and pricing of primary aluminium metal is dispensed with. The down stream industry has also been freed from licensing requirements. We have today three objectives.

- increase domestic production
- promote domestic consumption
- export metal and down stream products.

(ii) The international market of Aluminium is now made up of ores, alumina, metal, scrap and semis. India's role in international trading of aluminium and its products has been minor only so far. Though we produce about 0.45 MT of Aluminium every year, export of value added products have been negligible. However, there appears to be enough scope for export of bauxite and value added products like alumina, aluminium, semi-fabricated products for which necessary strategy has to be developed considering aspects of cyclic behaviour of market, domestic demands, long term tie-ups, power positions, preference for export of value added products etc.

(iii) Alumina has now emerged as a freely traded commodity, as it is delinked from captive smelter capacities. There is now general increase in trading of alumina in view of setting up of aluminium smelters in energy-rich countries like Latin America and middle east. The geographic location of India appears to offer attractive opportunities to service markets in far east, middle east, China and erstwhile USSR, as it is surrounded by an existing market of around 1.2 million tonnes needed by smelters in Dubai, Indonesia and Bahrain. With acute energy problems, it is also advantageous for India to convert part of its Alumina into metal in a country, where power is cheap.

(iv) With the increased rate of industralisation and expanding consumer population, it can also be safely assumed that domestic demand of aluminium will grow. The aluminium industry in India in the coming years, therefore, will always have to strive to keep pace with the domestic demands and it appears primary aluminium hereafter will be available for exports off and on even if exclusive export oriented facilities are not set up.

(v) Aluminium is considered as the metal of the next two decades and it could be treated as a thrust material for export and for increased use in the domestic sector. It has been represented in various quarters that demand in the domestic sector will increase substantially, if excise duty on aluminium is reduced. It has also been claimed that export can be increased if the Government can ensure supply of coal and fuel oil at international prices to the primary aluminium producers[16].

(vi) In the international market it appears there will be a short fall in the availability of metal from 1994 and by the year 2000 A.D. the short fall is likely to go up to as much as 1.3 million tonnes. Many new smelters are being planned in the advanced countries to fill up the short fall, and India also should not lag behind in creating additional capacity as abundant bauxite and coal reserves are available.

(vii) It appears that main problem for export of value added products is the disparities between quality of goods produced in India vis-a-vis requirement in the international market. Therefore, production of high quality products is very essential and necessary efforts are to be made.

(viii) Recycling of aluminium which requires organised scrap collection and processing. Secondary metal produced from recycled scrap will lead to substantial saving on power. Acute shortage of power has been eased to some extent by installation of captive power plants. State Electricity Boards however, should ensure enhanced power supplies. It has also to be kept in mind that Indian smelters have to compete with Brazilian, Middle East and Venezualian smelters, using very cheap hydro and gas based power.

(ix) The potential sectors for the use of aluminium should be identified and the use of aluminium in these sectors should be intensified. Suitable schemes in this regard will have to be worked out.

(x) Growth oriented fiscal policies may be formulated by the Government for encouraging growth in use of aluminium in specific sectors like transport, construction and packaging etc.[5]

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