

Aluminium Industry

14.1 Introduction

India has the fifth largest reserves of Bauxite in the world, the main raw material for making Aluminium. The per capita Aluminium consumption in India is only 1.6 kg as against 8 kgs in China and 30 kgs in developed countries. The World's average per capita consumption of Aluminium is about 10 times of that of India. The demand of Aluminium is expected to grow by about 9 percent per annum from the present consumption levels. India is a net exporter of Alumina and Aluminium metal. Four Aluminium plants in the country i.e., NALCO (National Aluminium Company Ltd.), HINDALCO (Hindustan Aluminium Company Ltd.), MALCO (Madras Aluminium Company Ltd. & BALCO (Bharat Aluminium Company Ltd.) account for the entire production of Aluminium in the country.

14.2 Present Capacity & Growth Potential

The total installed capacity of Aluminium is about 3% of the global capacity. The installed capacity in 2006-07 of Alumina & primary Aluminium was about 3.02 MT & 1.18 MT (Million tonnes) respectively. The production of Aluminium from 2004-05 to 2006-07 is shown in figure 14.1 below :

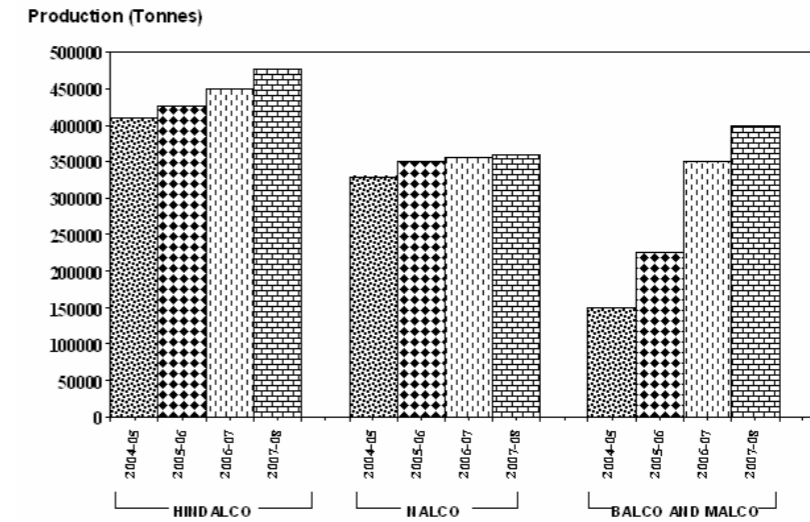


Fig - 14.1 : Production of Aluminium

(Source : The Energy Data Directory & Yearbook, Teddy, 2007 & individual company websites)

14.3 Aluminium manufacturing process

Primary Aluminium process consists of four stages :

- I. Mining of Bauxite
- II. Refining of Bauxite ore to produce Alumina (Bayer's process)
- III. Smelting of Alumina to produce Aluminium (Electrolysis process)

- Soderberg system
- Pre-baked system

IV. Casting & Rolling

14.3.1 Alumina Refining (Bayer's Process)

Alumina is the basic raw material for production of Aluminium and is obtained from Bauxite, a mineral containing upto 60% in the form of mono/trihydrate. The Bayer process is the most economical route for production of Alumina, used throughout the world. The production of Alumina from Bauxite is carried out through the Bayer route, an extractive hydro- metallurgical process which belongs to the alkaline group of processes.

Alumina production process consists of crushing and grinding of Bauxite with caustic liquor in ball/rod mills. The slurry after desilication is pumped into large tanks/autoclaves/tubes for digestion at 110°C to 300°C depending upon the mineralogy of Bauxite. The digested slurry is diluted and classified in thickeners. The overflow (Aluminate liquor) is pumped for controlled filtration and underflow containing red mud is washed / filtered and disposed to red mud pond. The filtered Aluminate liquor is cooled to 50-85°C in plate heat exchanger/flash tanks and pumped to precipitation tanks with addition of seed hydrate and retained for 30-75 hours with finishing temperature of 40-55°C depending on the type of Alumina to be produced. The precipitated hydrate slurry is classified and the coarser part (under flow) is filtered and washed to obtain the product hydrate and the fine part is recycled as seed hydrate. The hydrate containing 10-20% moisture, is calcined in rotary kilns/stationary calciners at 1000°C -1200°C to obtain calcined Alumina. Generally two tonnes of Bauxite is required to produce one tonne of Alumina.

Figure 14.2 shows the flow diagram of the Bayer Process & **Figure 14.3** shows the material balance for the production of one tonne of Alumina.

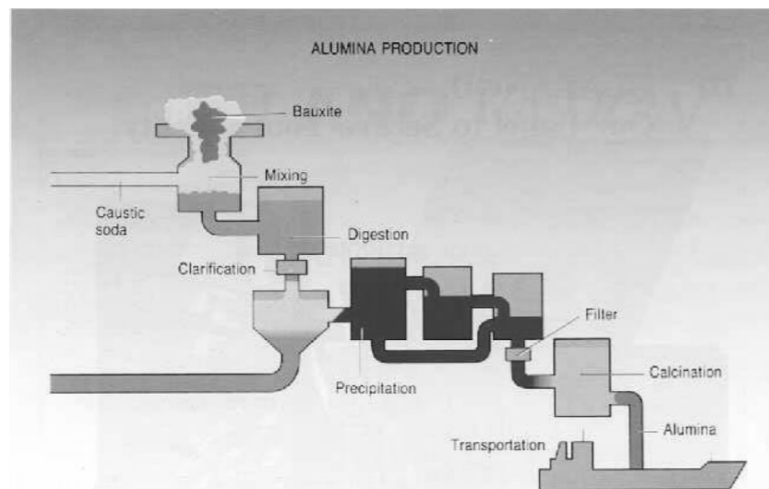


Fig 14.2 : Bayer's Process for production of Alumina

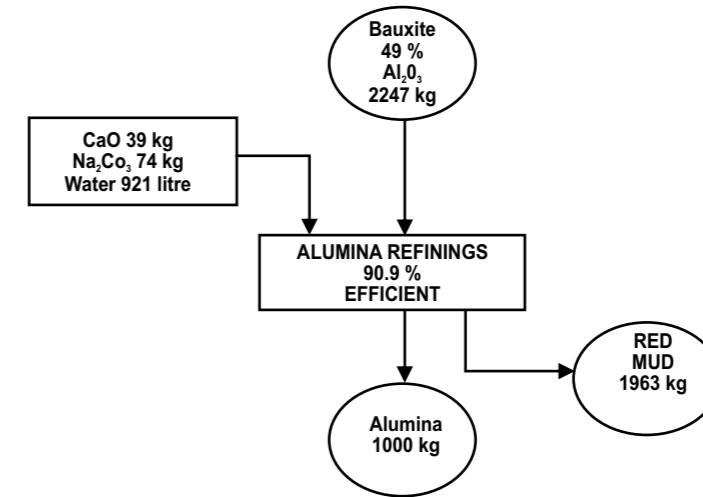


Fig 14.3 : Material balance for production of one tonne of Alumina

(Source : Investors Manual for Energy Efficiency; EMC; CII & IREDA)

14.3.2 Smelting of Alumina to Aluminium (Electrolysis process)

Alumina is the main input for the production of Aluminium through electrolysis process. The Aluminium metal is produced through electrolytic reduction of calcined Alumina, based on the process invented by C.M. Hall of USA and P.L.T. Heroult of France. However, there are two technologies used in smelting process i.e., Pre-baked system & Soderberg system.

The Pre-baked technology uses multiple anodes in each cell, which are pre-baked in a separate facility and attached to rods to suspend the anodes in the cell. New anodes are exchanged for spent anodes, i.e. anodes butts, recycled into new anodes. This technology is more prevalent in industries. The Soderberg technology uses a continuous anode which is delivered to the cell (pot) in the form of paste, which bakes in the cell itself.

In the Electrolysis process, Alumina is dissolved in fused electrolyte bath of cryolite at operating temperature ranging from 920°C to 970°C. Under the influence of high intensity direct current, Alumina gets dissociated to Aluminium and Oxygen ions in the electrolytic cells. Gases evolved are cleaned to recover the valuable fluorides and reduce the concentration of noxious contaminants before discharge to the atmosphere. Molten Aluminium is tapped from the bottom of electrolytic cells and cast into ingots, billets, etc. for conversion to semis. On an average, it takes 15.7 kWh of electricity to produce one kg of Aluminium from Alumina.

Thereafter, Aluminium semis covering flat and non-flat products are produced utilizing the processes of DC casting, continuous casting, extrusion, hot and cold rolling. Generally about two tonnes of Alumina is required to produce one tonne of Aluminium. Material balance for producing one tonne of Aluminium from Alumina is shown in **Figure 14.4** :

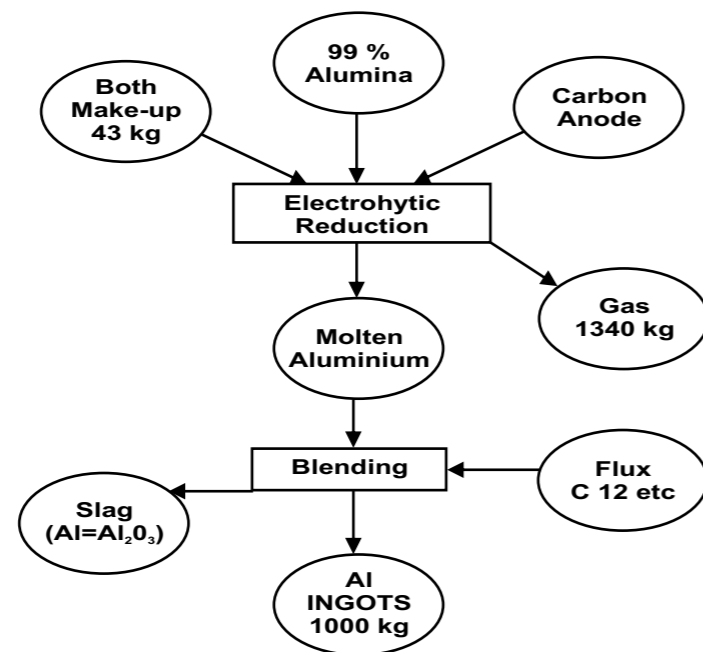


Fig 14.4 : Material balance for production of one tonne of Aluminium
(Source: Investors Manual for Energy Efficiency, EMC, CII & IREDA)

14.4 Energy Consumption in Aluminium Plants

14.4.1 Energy Intensity

Coal, furnace oil and electricity are primary energy inputs for Aluminium production. Coal is primarily used to generate steam, which is used in the process while fuel oil is mainly used in calcination of Alumina and various furnaces in fabrication plants. Electricity is the major energy input in Aluminium production and is considered to be a prime factor in determining economics of Aluminium production. Energy accounts for nearly 40% of Aluminium production costs for metal. Hence, all primary metal producers have installed their own captive power plants to have uninterrupted power supply for their use. Aluminium has a long working life and can be easily recycled. Recycling would require less energy i.e., about 5% of the total energy required to manufacture primary Aluminium from Bauxite.

As compared to the production of other metals, Aluminium industry is most energy intensive consuming energy to the tune of 80 GJ/tonne (including smelting) of metal, whereas Copper and Zinc production consumes 20 GJ/tonne and 15 GJ/tonne of energy respectively.

14.4.2 Specific Energy Consumption

The specific energy consumption in Indian Aluminium plants is quite high. It ranges between 75.6 GJ/t - 83.2 GJ/t (including smelting) for primary Aluminium. The specific energy consumption in smelting of Aluminium is 15000 - 16500 kWh per tonne. The operating efficiency in terms of energy consumption is only 40%, which theoretically should be about 5990 kWh per tonne of Aluminium metal.

The technologies adopted both in India & abroad are same but they differ in energy efficiencies as some of the units in India are still using self-baking anodes, (Soderberg technology) instead of multiple pre-baked anodes. 40% of the installed capacity in India is based on Soderberg technology, whereas 60% of it has switched over to the new more efficient pre-baked technology. The Aluminium plants have set a target of 1-2% reduction in SEC in the next 5 yrs. High electrical energy saving potential exists in the smelter section for the production of Aluminium. The major energy consumption in the Aluminium refining process (Bayer's process) are the digestion and calcination stages. About 30% of the total energy consumption is utilized in digestion process, whereas calcination consumes about 32% of the total energy. Typical energy consumption in different stages is given in the Table 14.1 :

Table 14.1: Typical Energy Consumption in Bayer's Process

Process	Energy (GJ/t)	% of total Energy Consumption
Preparation	0.37	2.3
Digestion	4.79	29.5
Settling / Washing	0.65	4.0
Precipitation	1.06	6.5
Evaporation	4.3	26.5
Calcination	5.07	31.2

(Source : Energy Requirements for Aluminium Production)

14.5 Energy Efficiency measures undertaken in Aluminium Plants in India

Most of the plants have implemented a number of energy conservation measures in the past and have specific plans to implement a few in the near future. Major energy conservation measures implemented during the last three years in this sector are given below:

14.5.1 Aluminium Refining

Medium term projects

- Installation of Programmable Logic Controller (PLC) controlled burners in furnaces.
- Installation of Variable Frequency Drives (VFD) for spent liquor pump feeding to evaporator
- Installation of VFD for red mud pond feed pump
- Installation of VFD for filtered aluminate liquor pump
- Installation of seal pots for condensate recovery in digesters, evaporators, HP and LP heaters
- Installation of VFD for spent liquor pump feeding to Plate Heat Exchanger (PHE)
- Optimizing the operation of filter feed pumping system
- Optimizing the operation of the slurry pumps in precipitation area
- Optimizing excess O₂ % in kiln by continuous monitoring
- Avoiding air infiltration in kiln by continuous monitoring
- Avoiding air infiltration in kiln flue gas exhaust line

- Replacing red mud filter vacuum pumps with new high efficiency vacuum pumps
- Utilizing the standby body in evaporator and increasing the steam economy

Long-term projects

- Installation of de-super heaters for better heat transfer and steam saving in Aluminium refining.
- Installation of energy efficient screw compressors.
- Installation of liquid vapour hydro cyclone in evaporation feed flash tank to avoid caustic entrainment to the hotwell water and facilities.
- Installation of thermo-compressor to recover flash steam from pure condensate tank in evaporator section.
- Segregation of pick-up and drying zone vacuum in red mud filters
- Sweetening the digestion process by adding Gibbsite Bauxite having higher solubility in downstream of higher temperature digestion circuit.
- Installation of technology upgraded recuperator in place of shell type in melting furnace.

14.5.2 Aluminium Smelter

Medium term projects:

- Installation of data acquisition system
- Installation of thyristor control in coke conveying vibrators in carbon plant
- Installation of correct size cooling water supply pump for rectifier cooling
- Installation of screw conveyor and avoiding the operation of a centrifugal fan in Carbon plant.
- Installation of variable frequency drive for fire hydrant pump
- Installation of variable fluid coupling for scrubber fans
- Reducing external bus-bar voltage drop across bypass joints and across rod to stud joints
- Improvement of insulation of sidewalls of the pots to minimize the heat loss due to convection and radiation

Long term projects

- Conversion of the Soderberg technology to the Pre Baked Cathode Technology in the pots
- Installation of point feeding in the Aluminium pots
- Coating of cathode surface of electrolytic cells with Titanium Boride (TINOR)
- Replacement of hot tamping mix with cold tamping mix
- Installation of variable fluid coupling for scrubber ID fans and avoiding damper control

14.6 Case Studies of Energy Conservation in Indian Aluminium Plants

Case Study 1 : Energy Conservation in Mining area

Brief

Selection of mining equipment is the thrust area for energy conservation in a mine. The NALCO mine is a highly mechanized mine operated with different types of suitable equipment. All the major HEMM (Heavy Earth Moving Machinery) are

diesel operated only. NALCO has introduced Trench concept of mining with staggered movement of faces following the mineralized thickness enabling economical extraction of ore. Selective extraction of contaminated ore at the bottom layer is another important feature of this method of mining. Each trench is mined in two distinct phases: Mass mining of bauxite up to a depth of 10 m by front end loader and dumper combination and selective mining of the remaining bauxite in contact with the wall in the 2nd phase by hydraulic back hoe shovel and dumper combination.

HSD accounts for over 90% of the power cost of the mine and 7% of the total mining cost, and the management had initiated lot of action in this area. PCRA had conducted the Energy Audit for the HEMMs deployed at this mine.

Energy Savings:

1. Recycling of hydraulic and transmission oil, contribute an annual saving of Rs 4.2 Million. It was proposed to adopt 'Electrostatic Liquid Cleaner in series with Vacuum Dehydration Machine' with a meager investment of Rs 0.4 Million. Annual consumption at the present production level is 35 kL of Hydraulic Oil and 50 kL of Transmission Oil.
2. Recycling of engine oil : The total annual consumption level is to the tune of 3000 kL. By recycling, Rs 1.4 Million can be saved, in addition to improving upon the engine efficiency.
3. Use of Mineral Water in radiators: An amount of Rs 0.57 Million can be saved annually by replacing the present system of using industrial water in radiators alongwith high value coolants.
4. Installing Load Cell in each Dumper : By installing load cells the percentage productivity of the dumpers when loaded by loaders can be improved and quantified. It has been observed that there has been wide variation at times in the percentage loading into the dumpers. By installing load cells in 14 nos. of 50Tonne dumpers, a total saving of Rs 0.34 Million can be achieved. Investment in installing load cells will be about Rs 1.2 Million and payback period is 3 years.
5. Construction of RCC road in permanent haul roads : This can generate a saving of Rs 1.7 Million due to improvement in engine life, fuel saving, better tyre life etc. Investment is Rs 14 Million.
6. Additive dosing in HSD: A total saving of Rs 0.57 Million can be achieved through improvement in efficiency of diesel operated HEMMs like dumpers, dozers, drills, loaders.
7. Performance improvement in blasting : Less generation of oversize boulders result in better productivity of loading and dumping machineries. This also improves productivity of the crusher due to less jamming, uniform feeding, resulting in better electrical motor life.

Some of the other Energy Conservation Initiatives undertaken by the mine are :

- Variable Frequency Drive in Crusher and conveying system
- Semi-Mobile Crusher Conveyor system

As part of their 6.0 Million Tonnes expansion plan NALCO management had approved commissioning of 'Semi-Mobile Crusher Conveyor' system. M/s ThyssenKrupp of Pune will execute the work at a cost of over Rs 1 Billion. This

will further reduce HSD consumption of the mine and the total energy bill, since this system will reduce the hauling length of the Dumpers.

Case Study 2 : Improved Energy through slotted anode

Brief

A mixture of computational and physical modelling techniques helps conserve energy by improving slotted anode designs, making aluminium reduction cells more efficient. The project was taken up by engineers in their plant. The reducing of 0.10 volt / pot has the potential of saving 325 kWh / t (at 94% current efficiency) & also enhance production of aluminium. In this system, the voltage saving was done by modifying the anode to 'slotted anode' to reduce bubble resistance. The slots were cut width-wise.

Energy Savings

1. Saving of 0.105 volts / pot led to the energy saving of 341 kWh/t aluminium.
2. Total Power saving is 116.62 million kWh per year.
3. Increase in potline amperage led to increase in smelter production of 8155 MT/yr.
4. GHG reduction by 357 kg CO₂ / MT or 122104 t CO₂/year @ smelter capacity of 342000 MT & emission factor as 1047 gm/kwh based on IAI guidelines.

Annual Saving : Rs. 434 Million (energy saving plus production increase)
 Investment : In-house design & modification.
 Payback Period : Immediate

Case Study 3 : Installing variable frequency drive for spent liquor pump feeding to evaporator

Brief

Variable frequency drive (VFD) with feed back control for the spent liquor feed pump to new evaporator was installed. Reduction in power consumption of about 400 units/day was achieved.

Energy Savings

Annual Savings : Rs 0.18 Million
 Investment : Rs 0.45 Million
 Payback period : 30 months

Case Study 4: Installing thermo-compressor and recovering flash steam from pure condensate tank in evaporator section

Brief

Thermo compressor was installed to recover the flash steam from the pure condensate tank and the recovered steam is sent to low pressure steam header.

The motive steam used is about 18-20 TPH at a pressure of 12 kg/cm².
 The schematic diagram of the modified system is shown in figure 14.5 below

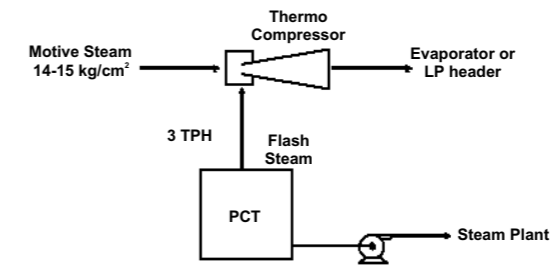


Fig 14.5 : Installation of thermo-compressor for recovery of flash steam

Energy Savings

Quantity of steam recovered : 3 TPH
 Annual Savings : Rs 5.48 Million
 Investment : Rs 3 Million
 Payback period : 7 months

Case Study 5 : Installing seal pot system for condensate recovery

Brief

The latest trend is to replace steam traps with seal pots wherever steam consumption is more than 1 tonne per hour. Seal pots were installed for condensate recovery in the following equipment:

- a) Digesters
- b) Evaporators
- c) HP heaters & LP heaters

Energy Savings

Steam saved : 250 Kg/hr.
 Annual Savings : Rs 0.45 Million
 Investment : Rs 0.75 Million
 Payback period : 20 months

Case Study 6 : Optimizing excess O₂ in kiln by continuous monitoring

Brief

Online oxygen analyser was installed and the % of oxygen level in the flue gas is continuously monitored. The combustion air supply to the kiln is controlled and percentage oxygen of 3% is maintained in the flue gas.

Energy Savings

Increase in combustion efficiency (%) : 2
 Annual Savings : Rs 2.95 Million
 Investment : Rs 0.7 Million
 Payback period : 3 months

Case Study 7 : Replacing old Horizontal Stud Soderberg (HSS) cells with modern point feeder prebake cells

Brief

It was proposed to revamp the entire system by installing modern point feeder pre-bake (PFPB) cells. The proposed system require energy consumption of about 990 million kWh/year to produce 29500 tonnes/year of aluminium.

The specific energy consumption for producing one tonnes of Aluminium during electrolysis would be 14kWh/kg (Electrical Energy).

Energy Savings

- Increase in energy efficiency of retrofit prebake cells : 10%
- GHG emission reduction : 50%
- Water consumption reduction : 30%
- Reduction in specific consumption of raw materials - Coal tar pitch, aluminium fluoride and petroleum coke.
- Annual Savings : Rs 84 Million

14.7 Energy Consumption (World's Best Practice)

The specific energy consumption of Aluminium plants in key developed countries ranges between 70.5 GJ/t - 73 GJ/t for primary Aluminium. However, considering the best processes in one of the best plants in the World, the SEC is 70.6 GJ/t of primary Aluminium. The specific energy consumption in smelting of Aluminium is 14000 - 14500 kwh per tonne. This is because of the best energy efficiency measures adopted. The 'World's Best Practice Values' for Aluminum production are given in table 14. 2 & 14.3 below. These values consist of:

- (i) Final Energy Intensity Values, i.e. Energy used at the production facility.
- (ii) Primary Energy Intensity Values, i.e. sum of the energy used at the production facility plus energy used to produce electricity consumed at the facility.

In this assessment, the energy used for Bauxite extraction is not included because it depends on the ore deposit characteristics. Also, the secondary Aluminium production is based on melting and reshaping scrap Aluminium.

Table 14.2 provides best practice final energy intensity values for the process steps for primary Aluminium production along with the best practice energy intensity value for secondary Aluminium production. **Table 14.3** provides primary energy values for these two Aluminium production processes.

Table 14.2 : World Best Practice "Final Energy Intensity" Values for Aluminum Production (values are per metric tonnes aluminium).

		Primary Aluminium		Secondary Aluminium	
		kgce*/t	GJ/t	kgce/t	GJ/t
Alumina Production (Bayer)	Digesting (fuel)	414	12.1		
	Calcining Kiln (fuel)	223	6.5		
	Electricity	48	1.4		
Anode Manufacture (Carbon)	Fuel	35	1.0		
	Electricity	7	0.21		
Aluminum Smelting (Electrolysis)	Electricity	1671	49.0		
Ingot Casting	Electricity	12	0.35		
Total		2411	70.6	85	2.5

*kgce= kilograms of coal equivalent
(Source: World Best Practice Energy Intensity Values for selected Industrial Sectors; LBNL; by Worrel E., Price L., Neelis M., Galitsky C. & Nan Z.)

Table 14.3: World Best Practice "Primary Energy Intensity" Values for Aluminum Production (values are per metric tonnes aluminium).

		Primary Aluminium		Secondary Aluminium	
		kgce/t	GJ/t	kgce/t	GJ/t
Alumina Production (Bayer)	Digesting (fuel)	414	12.1		
	Calcining Kiln (fuel)	223	6.5		
	Electricity	145	4.3		
Anode Manufacture (Carbon)	Fuel	35	1.0		
	Electricity	22	0.64		
Aluminum Smelting (Electrolysis)	Electricity	5064	148.4		
Ingot Casting	Electricity	36	1.06		
Total		5940	174.0	259	7.6

Note: Primary energy includes electricity generation, transmission, and distribution losses of 67%.
(Source: World Best Practice Energy Intensity Values for selected Industrial Sectors; LBNL; by Worrel E., Price L., Neelis M., Galitsky C. & Nan Z.)

14.8 World Best Practices for Energy Efficiency in Aluminum Industry

Considerable developments have taken place in the process for production of Alumina, Aluminium and semis in the developed countries. Some of these are given below :

14.8.1 Alumina Plants

- Use of rod mills with classifiers for wet grinding of Bauxite.
- Adoption of tube digestion system in order to achieve improved digestion yield.
- Adoption of Alcoa combination process for digestion and extraction of Trihydrate as well as Monohydrate Alumina.
- Adoption of direct filtration technology to separate the red mud directly downstream the digestion under the same conditions of pressure and temperature.

- Liquor purification system for removal of carbonates and organic matters.
- Improved mechanical agitation system for precipitators.
- Adoption of special disc filters for filtration of seed and product hydrate.
- Adoption of multistage falling film evaporation systems in place of conventional single stage system.
- Installation of stationary calciners in place of conventional rotary kilns.
- Adoption of dry disposal system of red mud.
- Automation and computerized process control systems for better operation of the plants.

14.8.2 Aluminum Smelters

- Improvement in electrolyte bath chemistry to minimize re-oxidation of metal.
- Improvement in Alumina feeding system by adopting point feeding for proper distribution of Alumina in the electrolyte.
- Improvement on magnetic field characteristics through bus-bar network redesign for stable metal pad.
- Increase in the current efficiency by accurate control of process parameters.
- Possibility of lowering anode current density by increasing the anode size.
- Replacement of monolithic cathode lining with prebaked cathode blocks for better cell life.

14.8.3 Semis Production

- New processes like CONFORM extrusion and hydro-static extrusion for improved extruded products.

14.9 Energy Efficient Technologies being used in Aluminum Plants in Japan

Case Study 8: Immersion melting plating furnace

Brief

A conventional furnace indirectly heats the metal in a vessel made of steel from outside through the vessel bottom or side wall. An immersion melting furnace is an energy-saving type furnace which heats the metal directly with a combustion-heating immersion tube. The furnace has a combustion-heating immersion tube integrated with a special gas burner made of ceramic, a temperature sensor, and specially-designed furnace-temperature control device.

Energy Savings

	Before Improvement	After Improvement	Saving / Improvement
Specific energy consumption (kCal/kg)	2500	700	1800
Holding energy consumption (kCal/kg)	62,000	23,000	39,000

Annual saving : Rs 1.8 Million (@65Kg./hr. production rate & 1600 hrs./yr. Operation & holding time of 2 hrs./day)
 Investment : Rs 2 Million
 Payback period : 13 months

Case Study 9: Installation of a small capacity variable pump for keeping hydraulic pressure

Brief

Even when pressure oil was not needed for the pressure-oil system, the main pump of the hydraulic unit was operated in order to compensate leaks. Instead, a small-capacity pump is installed to compensate leaks. The main pump operation requires 11 kW of electric power whereas, the small-capacity pump operation requires only 3.7 kW.

Energy Savings

Energy Savings (kW) : 7.3
 Annual saving : Rs 0.2 Million
 Investment amount : Rs 0.2 Million
 Payback: period : 1 year

Case Study 10: Variable Voltage Variable Frequency (VVVF) control of pumps and fume blowers, and flow rate reduction of by-pass circuit

Brief

In a rolling schedule, the time ratio between the rolling operation and the set-up operation is 3:2. The conventional method was as follows:

- 1) Coolant pumps and fume blowers were operated continuously.
- 2) During the set-up, output of the coolant pumps was returned to the coolant tank through the bypass by switching the 3-way valve. However, power consumption in the set-up time was greater than that in the rolling operation.

The following measures were taken:

- 1) The numbers of revolutions of the coolant pumps and fume blowers are controlled in accordance with the rolling schedule by introducing the VVVF apparatus.
- 2) Power consumption by the coolant pumps during the set-up time is reduced by throttling the valve of the bypass circuit to the coolant pumps.

Energy savings

Reduction of power consumption by VVVF control : 2 Million kWh/year
 Reduction of power consumption by throttling the bypass valve : 1.2 Million kWh/yr
 Annual Saving : Rs 2 Million
 Investment : Rs 4 Million
 Payback period : 2 years

Case Study 11 : Improvement of thermal efficiency for rapid aluminium melting furnace

Brief

Approximately 30% reduction of unit requirement of energy has been achieved through measures as :

- mixing of molten metal
- burner combustion control
- controlling the molten metal temperature
- controlling furnace pressure
- installation of recuperator.

Energy savings

	Conventional iron melting furnace	After improvement (immersion type holding furnace)	Saving/Improvement
Energy unit requirement (kcal/kg)	50 (100%)	22 (44%)	28
Yield (metal loss) (kg/T)	7 (100%)	2 (29%)	5

Energy savings

Energy savings (kL/yr.) : 184
 Annual saving : Rs 16 Million
 Investment : Rs 24 Million
 Payback period : 1.5 years

Case Study 12 : Regenerative burner type aluminium melting furnace

Brief

This improvement is to use a highly efficient furnace for melting aluminium. The furnace employs oil or gas fired regenerative type burners and reduces the specific fuel consumption by more than 30 % compared with a conventional melting furnace. Operating condition of furnace is 40 T/charge, 4 charges/day & 300 days/yr.

Energy savings

	Conventional melting furnace	Regenerative melting furnace	Effect
Waste heat recovery method	Recuperator	Regenerative substance (alumina ball)	-
Combustion air temperature	200° C on average	800° C on average	Increase by 600° C
Air ratio	1.2 on average	1.1 on average	Reduced
Waste heat recovery ratio	15.1 %	68.2 %	Increased by 53.1%
Specific fuel consumption	682 x 10 ³ kCal/t	478 x 10 ³ kCal/t	204 x 10 ³ kCal/t (30% reduced)
Heat efficiency	40.2 %	57.5 %	Increased by 17.3%
Reduction in crude oil equivalent			1,058.6 kL/year

Annual saving : Rs 10 Million
 Investment : Rs 28 Million
 Payback period : 3 years

Case Study 13 : Improving Operation by reduced number of revolutions of circulating fan

Brief

A circulating fan of a soaking pit was constantly operated at 100% of the number of revolutions from the start to the end of the operation. Energy saving is realized by the improvement of operation, where the number of revolutions of the circulating fan is reduced.

Following two points are found by controlling the number of revolutions of the circulating fan:

- 1) Reducing the number of revolutions of the circulating fan for a few hours after the start of heating does not change the heating time.
- 2) Reducing the number of revolutions of the circulating fan after the end of soaking gives no effects on material temperature.

Energy saving

From start to 3 hours : 70 kW to 35 kW
 After end of soaking : 56 kW to 28 kW
 Annual saving : Rs 2 Million
 Investment : Rs 2.8 Million
 Payback period : 1.5 years

Case Study 14 : Heat loss improvement of energy saving type electric holding furnace

Brief

This is an example of improvement of heat loss at electric holding furnaces used near the casting machine following the melting work of aluminium alloy ingot. Although individual energy consumption is not large, it has a huge effect considering that a number of electric holding furnaces have been already installed.

Energy savings

	Before Improvement	After Improvement	Saving/Improvement
Electricity consumption amount (kWh/y)	156,000	42,000	114,000
Crude oil saving amount rate (kL/y)	-	-	28

Annual saving : Rs 0.8 Million
 Investment : Rs 2 Million
 Payback period : 2.5 years

Case Study 15 : Improvement of operation of hot air circulation fan for the Aluminium annealing furnace

Brief

This is an example of remodeling the operation pattern of the hot air circulation fan of an annealing furnace for aluminium coil heat treatment to contribute to energy saving. The coil annealing furnace is a batch type electric furnace. Without replacing the existing motor, a frequency converter has been installed in the control board of the fan motor.

Energy Savings

	Before improvement	After improvement	Saving / Improvement
Production volume (t/y)	29,568	29,616	48 (increased)
Electric power consumption (kWh/y)	1,502,904	1,284,400	218,504 (reduced)
Electric power unit requirement (kWh/t)	50.8	43.4	7.4 (reduced)
Reduction converted into crude oil (kL/y)			53

Annual saving : Rs 1.6 Million
 Investment : Rs 2.5 Million
 Payback period : 1.5 years

14.10 Directory of ENCON Measures with expected benefits

14.10.1 Alumina

- Replacement of existing rotary kilns with stationary calciners.
- Adoption of tube digestion system for dissolution of predominantly monohydrate Bauxites.
- Removal of impurities from plant liquor.
- Adoption of dry disposal of red mud.
- Use of Variable Speed Drives for major process pumps and large motors in the plant.
- Provision of mechanical agitation or improved air agitation system in precipitation unit.
- Modernization of process control system in plants.

14.10.2 Aluminium

- Improvement in cell design
- Redesigning of bus bar arrangement.
- Provision of improved Alumina transportation system.
- Provision of mechanized and automated cell operations.

- Provision of dry scrubbing system for gas cleaning and recovery of fluorides.
- Computerisation of baking furnace firing system.

14.10.3 Semis

- Electromagnetic casting of slabs and billets.
- Hot top casting of billets with air-slip process.

(ii) Rolling

- Thin strip casting with cold rolling.
- Introduction of automatic gauge, flatness and crown control systems.
- Improved design features for heat treatment furnaces.

(iii) Extrusion

- Introduction of efficient heat treatment (Air & Water quenching on run-out table).
- Installation of combined direct/indirect extrusion press.
- Installation of Confirm extrusion process.

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