CHAPTER 2
OVERVIEW OF HINDALCO AND ITS PROCESSES

2.1 Aluminium Overview:
The Aluminium industry is the largest non-ferrous industry in the world economy. The production of the primary Aluminium from the Aluminium Oxide is power intensive process. Aluminium is the third most abundant element on the earth’s surface comprising 8% of the earth, after Oxygen (47%) and Silicon (26%). India is the 6th largest producer of Alumina and 8th largest producer of Aluminium in the world and also has the 5th largest reserves of bauxite with deposits of about 2.3 billion tonnes, which is 6.76% of the world’s deposits [23]. Today in the world, Aluminium production is about 44 million tonnes per annum and the big players are China, Russia, Canada, USA, Australia, UAE and India. China is the only country which produces 40% and India 5% of the total production of the world. About 40% Aluminium Smelters of the world are in China itself.

Today, the Aluminium industry in India is a highly concentrated sector with four major players, namely Bharat Aluminium company (BALCO), Korba (Chattisgarh), National Aluminium Company Orissa (NALCO) Angul (Odisha), Hindustan Aluminium industries (HINDALCO) and Vedanta Aluminium.

However, because of its strong chemical affinity, it is never found in nature as an element, but always in its oxidized form – most commonly in the form of Aluminates and silicates. Aluminium possesses a lot of attractive features that makes it a serious contender for a variety of applications. These features include:

- **Light weight** – with a specific weight of 2.7 g/cm³ which is one-third that of steel, it still exhibits a very high strength in comparison to other structural metals.

- **High resistance to atmospheric corrosion** due to thin film of oxide that is chemically formed on its surface.

- **Low melting point** - 660°C, if compared to steel (1500°C) and thus easily machined.
Good electrical conductivity
Non-magnetized
Good thermal conductivity
Easily alloyed to extend desirable properties
Practically infinite capacity for recycling

Aluminium finds a variety of uses. A non-exhaustive list includes:

Transportation
Automobiles, aircrafts, trucks, railway cars, marine vessels, bicycles

Packaging
Cans, foils

Electrical and Electronics
1. Outer shells of consumer electronics, cases for photographic equipment
2. Electrical transmission lines
3. Heat sinks for electronic appliances like transistors and CPUs
4. Super purity Aluminium in electronics and CDs

Aluminium compounds
1. Ammonium alum is used as a mordant, in water purification, paper production, food additive, leather tanning
2. Aluminium acetate is used as astringent
3. Aluminium borohydride is an additive to jet fuel
4. Aluminium hydroxide is an antacid
5. Many more such Aluminium compounds are in use

Construction
Aluminium alloys are used in a variety of structural applications.

Miscellaneous
1. Paint
2. Pyrotechnics such as solid rocket fuels and termite
3. Street lighting poles, sailing ship masts

Aluminium Growth in India Sector wise:
There has been an excellent growth in the domestic consumption in the last few years riding on the back of high GDP growth. Higher disposable income and acceptance of
Aluminium as a value proposition has contributed to this. The table below shows the consumption growth in the Transport, Construction and Electrical Segments in the industry.

Today India is the 5th largest Aluminium consumer in the world. The usage of Aluminium has been fuelled by the industrial growth particularly in Automobile and Building & Constructions Sectors apart from the traditional Electrical Sector. With the focus by the Govt. on infrastructure, the Electrical segment is expected to continue to be one of the largest users segments for at least next 10-15 years. Sector wise consumption of Aluminium in India in 2012 as shown in Table no.2.1

**Table 2.1: Sector wise consumption of Aluminium in India in 2012**

[Source: World-Barclays and Alcoa and India-company data]

<table>
<thead>
<tr>
<th>Sector</th>
<th>Consumption %</th>
</tr>
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<tbody>
<tr>
<td>Electrical</td>
<td>39</td>
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<tr>
<td>Transport</td>
<td>17</td>
</tr>
<tr>
<td>Building</td>
<td>15</td>
</tr>
<tr>
<td>Packaging</td>
<td>09</td>
</tr>
<tr>
<td>Machinery and Equipment</td>
<td>04</td>
</tr>
<tr>
<td>Other</td>
<td>16</td>
</tr>
</tbody>
</table>

**2.2 HINDALCO Overview and Its Process:**

HINDALCO was set up in collaboration with Kaiser Aluminium and chemicals corporation, U.S.A. in record time of 18 months. The plant started its commercial production in the year 1962 with a capacity of 20,000 tonnes per annum. While Aluminium production in India commenced in 1938 with the commissioning of Aluminium Corporation of India (INDAL) in collaboration with ALCAN, Canada having a capacity of 2500 tonnes per annum. HINDALCO gradually expanded its smelting capacity from an initial 20,000 TPY to the present 410,000 TPY by adding a number of pot lines but the basic design of the cells remained unchanged. However, HINDALCO utilized all those technological developments in the construction of 6th to 11th pot line which were established useful during modernization of first five pot lines.
in late eighties; such as improved cathode design, point feeding, microprocessor based process control system, mechanized Alumina conveying and improved anode design. Today HINDALCO ranks as the largest Aluminium producer in India and contributes about 40% share in total production (FY 2013-2014) of the country. The Company’s fully integrated Aluminium operation consist of the mining of bauxite, conversion of bauxite, conversion of bauxite into Alumina, production of primary Aluminium from Alumina by electrolysis and production of wire rod, rolled products, extrusions and values added products like foil and wheel. HINDALCO’s integrated operation and operational efficiency have enabled the company to be one of the world’s lowest cost producers of Aluminium. The company’s cost efficiency has helped it to record and outstanding performance in the face of adverse market condition. HINDALCO also owns a large captive thermal power plant at Renusagar, that meets the power requirement of the company very effectively. "Renusagar Power" a captive power plant, was set up to supply the most critical element for Aluminium production i.e. power. Situated at the pit head of the Asia’s biggest open cast coal mines, Renusagar power plant is the best performing power plant in India, and one of the best plant in the world, consistently operating at a plant load factor of above 90%. It generates about 770 MW of electricity to ensure an uninterrupted supply of power to HINDALCO Smelter. At present HINDALCO has an annual capacity of 4,10,000 tonnes of Aluminium, 98,000 tonnes rolled products, 91,000 tonnes of wire rod products and 33,000 tonnes extruded products. The Renukoot operation span across the entire value chain commencing from Bauxite mines, transportation of Bauxite, processing of the Bauxite at the Alumina Plant to produce Aluminium Oxide powder, power generation, reduction of Alumina in Smelter plant for production of primary Aluminium metal and value added products in Fabrication Plant, delivery of the finished goods to the customers, numbering over 30,000 different items, dealers, stockists, intermediary producers as well as the end users of HINDALCO products with providing after sale service.

In Fig. 2.1 integrated operations of HINDALCO have been presented with respective capacity of each plant.
2.2.1 HINDALCO Alumina Refinery and its Process.

Alumina Plant of HINDALCO operates on Bayer’s process (predominantly used in Alumina Refining Industry worldwide), wherein cost-effectiveness and technological edge are derived primarily from ‘Mineralogy of Bauxite Ore’. Bauxite ore is mined by the open cast method at Lohardaga, Richiguta in Bihar and at Samri in MP. The ore is collected and transported by trucks or ropeway to the nearest railhead for onward transportation to Alumina Plant at Renukoot, which is at a distance of 150kms.

HINDALCO Alumina Refinery uses High-Temperature Digestion Technology to process hard bauxite. Refinery started with a humble capacity of 40,000 MTPA in 1962 and its capacity has been enhanced over the years, primarily by in-house efforts and continuous technological up-gradation. Today its capacity is 719,000 MTPA. Alumina is a basic raw material for Aluminium production. Consumption per tonne depends upon its purity and dusting losses during handling. Consumption varies from 1.92 MT/MT Al to 2.00 MT/MT Al. For Aluminium production the cost of Alumina accounts nearly 30-35% of operating cost.

Smelter grade Alumina in HINDALCO is manufactured by conventional Bayer’s process i.e., treating Bauxite with Caustic Soda. Bauxite is brought from various Mines to the site by means of Railway wagons, which are unloaded at Wagon Tippler. It is crushed to a lump size of minus 4 and stockpiled. Secondary crushing of Bauxite is done in Hammer Mills to reduce its size to minus ½. Wet grinding of this crushed
bauxite is done in Ball Mills with process liquor known as Spent Liquor to obtain bauxite slurry consisting of 50% solids.

De-silicated and pre-heated Bauxite slurry is pumped into the Digesters and direct heating system through slurry heaters where Alumina content of bauxite is dissolved into caustic solution at 240°C temperature and 36 kg per sq.cm pressure.

The digested slurry is flashed for heat recovery in Flask Tank trains. Flashed vapours are utilized for pre-heating the spent Liquor and condensate is returned to boiler house for generation of steam. Digested flashed slurry is pumped to clarification area for removal of solid impurities. Sand is separated out in soil liquid hydro-cyclone and mud in Settler. The separated mud slurry from settler is washed with hot water in a counter-current washing circuit. Washed mud slurry is partly causticised by treating with lime slurry and this partly causticised slurry is thereafter filtered on Drum filters. Drum filtrate liquor is taken back to the system and Red mud cake is disposed of in the earmarked area by Dumpers.

The settler overflow i.e. Pregnant Liquor is filtered in Kelley Presses to remove fine suspended mud particles. The clear pregnant liquor is pumped to precipitation circuit to obtain Alumina tri-hydrate. The classified Alumina tri-hydrate slurry is filtered and is fed to two energy efficient claciners to finally get Alumina powder.

The detailed chemical reactions of Bayer’s process are given below:

2.2.2 Reactions Governing Bayer’s Process

De-silication

\[
5[\text{Al}_2\text{O}_3.2\text{SiO}_2.2\text{H}_2\text{O}.2\text{H}_2\text{O}]+2\text{Al} \rightarrow (\text{OH})_3+12\text{NaOH}
\]

\[
2[\text{Na}_2\text{O}.3\text{Al}_2\text{O}_3.5\text{SiO}_2.5\text{H}_2\text{O}] + 9\text{H}_2\text{O}
\]

(Desilication Product)

Digestion

\[
\text{Al}_2\text{O}_3.3\text{H}_2\text{O} + 2\text{NaOH} \xrightarrow{240°C, 36\text{kg/cm}^2} 2\text{NaAlO}_2 + 4\text{H}_2\text{O}
\]
Precipitation

\[
2 \text{NaAlO}_2 + 4 \text{H}_2\text{O} \xrightarrow{60°C} \text{Al}_2\text{O}_3.3\text{H}_2\text{O} + 2 \text{NaOH}
\]

Calcination

\[
\text{Al}_2\text{O}_3.3\text{H}_2\text{O} + \text{heat} \xrightarrow{1200°C} \text{Al}_2\text{O}_3(\text{s}) + 3\text{H}_2\text{O}
\]

-- Production rate (in house) @ 2000 MT/day

-- Consumption rate \(\frac{2050 \times 0.935 \times 8.052 \times 64 \times 1.94}{1000}\) = 1916 MT/day

@ 1.94 MT/MT of Al.

2.3 HINDALCO Aluminium Smelter

2.3.1 Introduction

The Company produces Aluminium in smelting facilities that include eleven pre-baked pot lines with a total of 2000 pot cells, giving the Company an effective capacity of 410,000 TPA of Aluminium. These cells convert Alumina into metallic Aluminium by the standard Hall Heroult process, in which electrolysis of the Alumina takes place in a molten bath of cryolite [16].

The Company commenced production with one potline in 1962, and in subsequent years installed additional pot lines. The Company has modernized its pot lines through various measures, including re-design of the cathodes that conduct electricity through the pot cells, improving the Alumina feed system and computerizing the operation and energy use of the cells. These measures have substantially improved the energy efficiency and extended the useful life of pots, enhancing the company's ability to compete with newer Smelters.

The smelting process consumes carbon anodes. It generally requires about one half tonnes of anodes to produce one ton of Aluminium. The Company manufactures its own anodes in its carbon plant by baking a mixture of petroleum coke and hard pitch.
2.3.2 Principles of Aluminium Electrolysis

Electrochemistry is the study of processes involved in the inter conversion of electric energy and chemical energy generally in ionically conducting media.

Aluminium electrolysis is such process where media is electrolyte (molten salts or bath). Other than the media, it requires the following.
1) Anode (a positively charged electrode made of carbon)
2) Cathode (a negatively charged electrode made of carbon)
3) The current (which flows from anode to cathode)

The basic electric circuit of electrolysis is shown in fig. 2.2

![Basic electric circuit of electrolysis](image)

Fig. 2.2: Basic electric circuit of electrolysis

A. Effect of current

**Faraday’s laws of electrolysis**

**First law**: - The chemical action produced or the mass deposited at electrode is directly proportional to the quantity of electricity passed or the charge flowing in the electrolyte.

**Second law**: - If same charge is flowing in different chemical processes, then the masses of different elements deposited on electrodes are directly proportional to their chemical equivalent weights.

Faraday’s constant (96500 coulombs) will deposit 1 gm equivalent of an element at electrode.
Atomic weight of Al = 26.98 gms.
Valency of Al = 3
Equivalent weight of Al = 26.980/3 = 8.99333 gms.
96500 coulombs of charge will deposit 8.99333 gms of Al at cathode
1 ampere current for 24 hours = 1 \times 24 \times 60 \times 60 = 86400 coulombs

Therefore Aluminium deposited on cathode for 1 ampere current during 24 hours = 
8.99333 \times 86400/96500 = 8.052 gms. (Theoretically)
= 0.008052 Kg (Theoretically)

Metal production in tonnes per day
\[
\frac{0.008052 \times \text{V} \times \text{A} \times \text{t} \times \text{R}}{1000}
\]

At the HINDALCO Smelter, pot lines are operated at 70KA and number of pots in each pot line are about 200. The theoretical production of each pot line is therefore
0.008052 Kg \times 70KA \times 200 = 112.728 tonnes/day.

The current efficiency is defined as the ratio of actual production to the theoretical production.

\[
\text{current efficiency} = \frac{\text{Actual production}}{\text{Theoretical production}}
\]

(B) Effect of potential difference or voltage

\[
2\text{Al}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Al} + 3\text{CO}_2
\]

1. Dissociation voltage for the above = around 1.18 Volts
2. Concentration polarization: Ions must be discharged by migration, agitation and diffusion on electrodes. If it is not done then there is concentration gradient of ions at electrodes which causes change in the reversible electrode potential known as concentration over voltage or concentration polarization.
3. Total voltage required to dissociate and discharge the ions = around 1.60 Volts.
2.3.3 Smelting Process

Aluminium smelting is the process of extracting Aluminium from its Aluminium Oxide. This is done by an electrolysis process which requires a dc current source. The electrolysis process takes place in a large number of series connected steel ports collectively referred to as a pot line. The AC supply is given to the pot line through the Regulating Transformer, Rectifier Transformer and AC-DC converter. The smelting process is a nonstop process with a particular constant load throughout the year [23].

During electrolysis, Aluminium Oxide (Al₂O₃) gets dissociated in Aluminium and oxygen ions. Aluminium deposits at cathode and oxygen reacts with carbon to form CO₂. Net reaction can be shown as below:

\[ 2 \text{Al}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Al} + 3\text{CO}_2 \]

Alumina consumption depends upon its purity and losses during its handling. Alumina is dissolved in molten cryolite bath and electrolysis is carried out in specially designed Aluminium electrolysis cells commonly known as ‘pots’. “Faraday Law of Electrolysis” governs electrolytic process.

A number of electrolytic cells connected in series along with certain bus bar configuration for passage of current and spread over two rooms constitute a potline as shown in fig 2.3.

![Cells Arrangement of the Smelter](image)

Fig. 2.3: Cells Arrangement of the Smelter
An Aluminium reduction cell at HINDALCO consists of a rectangular steel shell, 9-12m long by 3-4 m high, lined with refractory thermal insulation that surrounds an inner lining of carbon to contain the highly corrosive fluoride electrolyte and molten Aluminium [14]. The system of Aluminium smelting process has been shown in figure no 2.4

Fig. 2.4: Aluminium smelting process

Electric current enters the cell through 24 prebaked carbon anodes. Cells are generally fed Alumina at centre of pot, in frequent small doses by point feeders. Thermal insulation is adjusted to provide sufficient heat loss to form a protective ledge of frozen electrolyte (that often contains undissolved Alumina) on the walls of prebaked anode cell, but not at the bottom of the cell cavity. The bottom must remain bare to provide electrical contact with the molten Aluminium cathode. This frozen ledge thermally and electrically insulates the sidewalls and prevents their acting as cathodes and being eroded by formation of Aluminium carbide. This undesirable Aluminium carbide, which forms at higher bath temperature, dissolves in the molten electrolyte. The ledge acts to stabilize the temperature of the electrolyte by freezing to a greater thickness with a fall in power input and thinning with a power increase.
The anode-to-cathode spacing ranges from 3-6 cm. Steel collector bars keyed into the carbon lining to carry the electric current from the cell. Today’s cells range in current capacity from 50-350 x 10³ amperes. The modern technology used in Aluminium Smelter employs smelting current as high as 500 KA [1] whereas Renukoot Smelters were designed in the range of 58 KA to 70 KA pot cells. Technology used in Aluminium Smelters could be broadly classified on the basis of current and pot size with higher current translating into higher power efficiency and thereby cost effectiveness.

Few important Performance Indicators for Smelter:

- Line Current (KA)
- Specific Power Consumption (DC KWH/MT Al)
- Current Efficiency
- Volts/Pot
- Specific Gross & Net Carbon consumption (Kg/MT Al)
- Specific Aluminium Fluoride consumption (Kg/MT Al)
- Alumina consumption factor (T/T of Al)
- Pot life
- Man hours/MT Al
- Purity of metal i.e. % Al in metal
- % Contamination of following elements
  - Silicon
  - Iron
  - Other minor impurities like Titanium, Vanadium, Gallium, Copper and Manganese etc.

### 2.3.4 Bath Chemistry

The process of controlling bath composition to give maximum current efficiency and minimum pot voltage is called Bath chemistry control.

The electrolyte for Aluminium Production is bath which has the following composition.
Table 2.2: Composition of bath

<table>
<thead>
<tr>
<th>Compound</th>
<th>%age</th>
<th>Compound</th>
<th>%age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryolite (Na₃AlF₆)</td>
<td>80.0</td>
<td>AlF₃ (Excess)</td>
<td>11.0</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>3.0</td>
<td>CaF₂</td>
<td>5.5</td>
</tr>
<tr>
<td>MgF₂</td>
<td>0.5</td>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Molten Cryolite (Na₃AlF₆) is the major component of the Hall-Heroult Electrolyte process. Cryolite has a uniquely high solubility for oxides. Operating temperature is lowered by additives from over 1000°C, for pure Cryolite, to 940-960°C. Aluminium fluoride (AlF₃) and Calcium fluoride (CaF₂) are the most common additives.

2.3.5 Parameters being maintained at HINDALCO Smelter for a cell

- Excess of AlF₃ in Na₃AlF₆ -- 6.5%
- Cell age --- 2800 days
- Carbon consumption -- 0.42 kg/kg Al
- Current density -- 1.27 A/cm²
- Current efficiency --- 94%
- Anode Cathode Distance ------ 45-55 mm
- Cell electric consumption ---- 14.010 kWh/kg-Al
- Current --- 68 KA (Average)
- Metal height ---- 9 - 10 cm
- Metal production ---- 525 kg-Al per cell per day
- Reactivity Residue (kg) it is only associated with the average of anodic residues --- 10%
- Bath temperature ------ 956 °C
- Cell voltage ------ 4.30V
- Anode voltage drop ---- 135mv
- Bath voltage drop ---- 1.95 volts
- Cathode voltage drop --- 335 mv
- Decomposition voltage drop.---- 1.60 volts
2.3.6 Specific Power Consumption for Aluminium Production

Aluminium production is a power intensive process. It requires a lot of electrical energy to convert refined Aluminium Oxide into Aluminium through electrolytic process. Power cost accounts for 30-40% of operating cost. AC power received from power generation source is converted into DC through converters to feed to the pot lines.

Power consumption largely depends upon Volts/pot and current efficiency:

\[
\text{Power Consumption/Kg Al} = 2.9806 \times V / \eta \\
V \quad - \quad \text{Volts/pot} \\
\eta \quad - \quad \text{Current Efficiency}
\]

This is DC power consumption and unit is DC KWh/Kg Al.

In case of pot line 7, the following losses have to be added in the DC power consumption to calculate AC power consumption at source.

**Converter Transformer Loss**
- **a)** Iron Loss
- **b)** Copper Loss

**Thyristor Loss**
- **a)** Loss/device = Idc /3 (Uto + rT.Idc)
- **b)** Total Thyristor loss = device loss \times number of devices

**Fuse Loss**
- **a)** Fuse Resistance = (from fuse rating)
- **b)** Loss/fuse = I_F^2 R  
  \( R \) is the resistance of the fuse. 
  \( I_F \) = Current/fuse.

**Snubber Loss**
- **a)** Loss/Snubber group = f (7/2 C U_{20}^2 [\sin^2 \alpha + \sin^2 (\alpha+\mu)]/2 + L_T I_F^2)
- **b)** Total Snubber Loss = Loss/Snubber group \times (12=No. of groups)
AC Busbar Loss
Total AC Bus bar Loss = (Calculated from the actual length of bus bar segments)

DC Busbar Loss
Total DC Bus bar Loss = (Calculated from the actual length of bus bar segments)

AUX Loss
a) Pump and fan Loss
b) Oil Pump loss
c) DM Water Pump loss
d) Heat Exchanger Fan loss
e) Radiator Fan loss

The total Thyristor Converter Losses thyristor converter are 552 KW as per the test report of Ms ABB.

2.3.7 Efficiency of Rectification
The efficiency of rectification is defined to be the ratio of dc output power to the ac input power of the converter.

Rectification Efficiency = DC Power Consumption/AC Power Consumption.

2.3.8 Losses Due To Power Trouble
In instances of issues of power, pots have to be closed down to match overall power requirement with power available from source. Pots are put out of circuit (closed) in three ways:

Putting crossover to take the pots out of circuit in mass.
Putting shunts across high life or abnormal pots within crossover.
Disconnecting pots failed due to abnormal operation.

Pots which are closed by putting cross over and not having achieved normal life are started after maintenance called dressing. Frozen electrolyte of pot is dugout and pot blasted at higher voltage after putting new anodes in it. Blasting involves lot of energy
& carbon burning. Pots also run at higher voltage & lower current efficiency for extended period.

Pots, which are closed by putting shunts or failed due to abnormal operation and are of high life are normally started after maintenance called full lining. Entire frozen electrolyte, metal & lining material including cathode block is dugout and pot is rebuilt with new cathode blocks and lining materials. It takes around 10-11 days thereafter pot is restarted after cathode baking. Restarting involves lot of energy, carbon and electrolyte losses besides pots running at lower current efficiency for around 2 months.

Pots, which fail due to abnormal operation and life is less than around 2300 days, normally are started after maintenance called side lining. Electrolyte metal & side-lining material is dugout and sides of such pots are rebuilt with new lining materials. It takes around 8-10 days before pot is restarted after cathode baking. Restarting involves lot of energy, carbon and electrolyte losses besides running of pot at lower current efficiency for around 2 months.

2.4 Overview of HINDALCO Rectifier Sub Stations

The Aluminium industry needs continuous and uninterrupted power supply and availability of assured power supply on continuous basis. HINDALCO gets power from two sources i.e. captive power plant Renusagar and Rihand, UP Grid. HINDALCO expanded in a stepped manner therefore there are two rectifier substations. HINDALCO has plant 1 Rectifier substation and plant 2 Rectifier substation. HINDALCO Plant-1 Sub-station receives power through two 132KV transmission lines deploying GOAT (630Amp) conductors from Renusagar and ‘PANTHER’ (207 sq.mm Aluminium equivalent, current rating: 520Amps at 40°C & 482 Amps at 45°C) conductors from Rihand Hydel power station (UP).

HINDALCO Plant-II receives power at 132KV through four feeders from Renusagar deploying GOAT conductor (316.5 sq.mm Aluminium equivalent, current rating: 680 Amp at 40°C & 630Amps at 45°C) and ZEBRA conductor (418.6 sq.mm Aluminium equivalent, current rating: 795Amps at 40°C & 735 Amps at 45°C) and AAAC conductors (960 Amp). Both the Rectifier substations are interconnected through two tie lines from Plant-I to Plant-II deploying AAAC Scorpion Conductors. There are
two 132KV buses in the switchyard. One bus is a normal bus and the other is standby bus. The two buses are connected through the bus coupler.

In Fig. no. 7, total network of power supply system to the pot lines of HINDALCO has been shown. In this network, the rated capacity of each generators of captive power plant Renusagar and co-generation units 1 & 2 of HINDALCO Alumina plant had been shown.

![Diagram](image.png)

**Fig. 2.5: HINDALCO total network single line diagram**

Pot lines 7 and 9 are connected at the main bus bar of rectifier substation of Plant II as shown in Fig. 2.5. In pot line 7 there are two converter transformers each of 74.3 MVA which step down voltage from 132KV to 796V - 804V. Through thyristors converters the AC voltage is converted to 900V DC [32]. To supply the DC power to Pot line 7, one converter transformer is capable of taking full load of the pot line. In pot line 9 also there are two units to supply the power to the Regulating Transformers of 81.52 MVA which regulate voltage from 6.3KV to 83.1KV, with its input supply of 132 KV. These Regulating Transformer feed to Rectifier Transformers which
further reduces the voltage to 743 - 750 V. Diode converters are installed to convert the AC voltage to the rated 900V DC [29]. All the 11 pot lines of HINDALCO Aluminium Smelter have been connected at rectifier substations 1 and 2 as shown in above Fig.2.5.