Pre-Feasibility study of Copper Smelter Plant –II
1.0 INTRODUCTION

About the Company

Vedanta Ltd., is a group company of Vedanta Resources Plc. London. Vedanta Limited is one of the world’s largest diversified natural resource companies listed on BSE, NSE and NYSE. Vedanta Ltd., produce copper, zinc, lead, silver, aluminium, iron ore, oil & gas and commercial power and have a presence across India, South Africa, Namibia, Ireland, Australia, Liberia and Sri Lanka. Sustainability is at the core of Vedanta’s strategy, with a strong focus on health, safety and environment and on enhancing the lives of local communities.

Vedanta Ltd., has a strong track record in managing operations and improving costs and output. Indian zinc and copper operations rank in its top quartile of global cost efficiency.

Vedanta Ltd., is the first company in India to set up a Copper Smelter and Refinery in private sector and operate the largest capacity continuous Cast Copper Rod plants. The main products are Copper Anodes, Cathodes and Rods, which meet global quality benchmarks.

Project Background

The first integrated copper Smelter -I complex at Thoothukudi was commissioned for commercial production during 1997. The company owns copper mines in Australia and remaining requirements of copper concentrate is imported from Chile, South America, Australia and Indonesia.

The proposed Copper Smelter –II project is a green field project.

Production Capacity

The production capacity of Copper Smelter Plant –II is presented in Table-1.

**TABLE-1**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Products</th>
<th>Units</th>
<th>Plant –II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I</strong> Main Products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Copper Anode</td>
<td>TPD</td>
<td>1200</td>
</tr>
<tr>
<td>2</td>
<td>Copper Cathode (from anodes produced)</td>
<td>TPD</td>
<td>1525</td>
</tr>
<tr>
<td>3</td>
<td>Continuous Copper Rod (from cathodes produced)</td>
<td>TPD</td>
<td>800</td>
</tr>
<tr>
<td>4</td>
<td>Phosphoric Acid</td>
<td>TPD</td>
<td>800</td>
</tr>
<tr>
<td><strong>II</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Anode slime (refinery)</td>
<td>TPD</td>
<td>3.0</td>
</tr>
<tr>
<td>6</td>
<td>Dore Metal (from Anode Slime produced)</td>
<td>TPD</td>
<td>0.650</td>
</tr>
<tr>
<td>7</td>
<td>Selenium (from Anode Slime produced)</td>
<td>TPD</td>
<td>1.200</td>
</tr>
<tr>
<td>8</td>
<td>Bismuth Bi sulphate (from foul Electrolyte produced)</td>
<td>TPD</td>
<td>1.800</td>
</tr>
<tr>
<td>9</td>
<td>Copper telluride</td>
<td>TPD</td>
<td>0.600</td>
</tr>
</tbody>
</table>
**Significance of the Project**

Copper application areas covers wide varieties of different disciplines like, Architectural, Electrical, Automotive, Tube, Pipe, Fuel gas, Industrial, Marine and Machine products which gives a great demand.

Copper is a strategic metal for development of industry in India. It is considered to be the third most important industrial metal next only to iron and aluminium. Combination of its excellent properties such as high electrical and thermal conductivity, high strength, malleability, easy workability, corrosion resistance and its ability to produce alloys with other metals in an attractive range of colours has made copper a strategic metal for the engineering industry. Specific applications of copper include power cables and wires, jelly filled cables, building wires, air conditioning and refrigeration tubing, Telecom, Power, Construction, Transportation, Handicrafts, Engineering, Consumer Durable, Defence, etc. With Indian economy poised for growth, development in infrastructure and power sector will lead to demand of copper. The per capita consumption of copper in India is only in the range of 0.5 kg, when compared to China's per capita consumption of approx. 4.6 kg and world average of 2.4kg. (Source: Ministry of Mines, Govt. of India).

Prior to setting up of the Copper Smelter at Thoothukudi by the Company (Vedanta Ltd.), the country was a net importer of Copper. Post setting up of the copper smelter by the Company, the country is able to earn valuable foreign exchange and hence improves the Current Account Deficit.

**Description of Plant Site**

Copper Smelter Plant -II is located in the SIPCOT Industrial Complex, Therkku Veerapandia Puram Village, Thoothukudi. The Total area earmarked for is 128.805 Hectare of land allotted by State Industries Promotion Corporation of Tamil Nadu Limited, (SIPCOT), a Government of Tamilnadu undertaking specially for promoting industrial development.

State Industries Promotion Corporation of Tamil Nadu Limited (‘SIPCOT’) handed over land of 131.3 ha for 1200 TPD Copper smelter Plant – II. SIPCOT and executed three lease deeds, one, dated 16-02-2009 (for 36.16 hectares of land), the second, dated 07-10-2009 (for 93.33 hectares of land) and the third dated 03-06-2010 (for 1.84 hectares) in favour of the Company at SIPCOT Industrial Complex, Thoothukudi and handed over the land as per lease agreements to the Company.
Copper Smelter –II will be located in 128.805 ha. and the Land kept in hand in Zone –A for future purpose is 2.585 ha.

The location map and study area of 10-km radius of the plant is shown in Figure-1 and Figure-2 respectively.

Environmental Setting of the Plant Site

The environmental setting of the plant site is given in Table-2.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Latitude</td>
<td>Northwest-08°50’29.9”N 78°04’12.9”E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Southwest-08°49’45.3”N 78°04’05”E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Southeast-08°49’32.9”N 78°04’40.7”E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Northeast-08°49’58.8”N 78°04’47.8”E</td>
</tr>
<tr>
<td>2</td>
<td>Elevation above MSL</td>
<td>20-m above Mean Sea Level</td>
</tr>
<tr>
<td>3</td>
<td>Climatic conditions</td>
<td>As per IMD Thoothukkudi:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual Mean Max Temp          : 38.3° C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual Mean Min Temp          : 19.4° C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average Annual Total Rainfall :625.8 mm</td>
</tr>
<tr>
<td>4</td>
<td>Present land use</td>
<td>Industrial Area</td>
</tr>
<tr>
<td>5</td>
<td>Nearest Highway</td>
<td>NH-45B Connecting Madurai and Thoothukkudi (1.5-km, SE)</td>
</tr>
<tr>
<td>6</td>
<td>Nearest Railway Station</td>
<td>Milavittan (2.0-km, SE)</td>
</tr>
<tr>
<td>7</td>
<td>Nearest Airport</td>
<td>Vaagaikulam (12-km, W)</td>
</tr>
<tr>
<td>8</td>
<td>Nearest Town/City</td>
<td>Thoothukkudi (8.4-km, ESE)</td>
</tr>
<tr>
<td>9</td>
<td>Hills/valleys</td>
<td>Nil within 10-km radius</td>
</tr>
<tr>
<td>10</td>
<td>Archaeologically important places</td>
<td>Nil within 10-km radius</td>
</tr>
<tr>
<td>11</td>
<td>National Parks/ Wildlife Sanctuaries</td>
<td>Nil within 10-km radius</td>
</tr>
<tr>
<td>12</td>
<td>Reserved / Protected Forest</td>
<td>Nil within 10-km radius</td>
</tr>
<tr>
<td>13</td>
<td>Seismicity</td>
<td>Zone-II</td>
</tr>
<tr>
<td>14</td>
<td>Streams/Rivers</td>
<td>No major rivers within 15-km radius</td>
</tr>
<tr>
<td>15</td>
<td>Defence Installations</td>
<td>Nil within 15-km radius</td>
</tr>
<tr>
<td>16</td>
<td>Port</td>
<td>Thoothukudi Port (17-km)</td>
</tr>
<tr>
<td>17</td>
<td>List of Industries within 7-km radius</td>
<td>1. M/s VV. Titanium Pigments Pvt. Ltd, Thoothukudi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. M/s. Tuticorin Spinning Mill</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Small scale industries in SIPCOT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Ind Bharath Power Plants</td>
</tr>
</tbody>
</table>
FIGURE-1
LOCATION MAP OF THE PLANT
The SIPCOT industrial complex is fully developed industrial estate provided with all types of infrastructure facilities such as road, rail and goods yard, water supply, drainage etc. The SIPCOT area is well connected by road and rail. Power is readily available through separate sub-stations. Thoothukudi port is located at a distance of 17-km, which provides additional advantage and facilities for import and export of materials required by the industries in the region.
1.1. **Smelter Operation**

The copper anodes are produced from the imported copper concentrate through pyro-metallurgical (smelting) processes. The sulphur dioxide generated during the smelting of copper is converted into sulphuric acid by Double Conversion Double Absorption (DCDA) process. A part of this sulphuric acid is captively utilized for production of phosphoric acid from the imported rock phosphate using a Hemi-hydrate-Di-hydrate process. The copper anodes are next dispatched to the refinery unit for further electrolytic refining to about 99.99% purity, which is necessary to obtain the required electrical conductivity for electrical applications.

The principal raw material for the production of copper metal at Vedanta Ltd., is copper concentrate containing about 25-35% copper, 25-32% sulphur, iron 25-30% and 7-10% moisture. The major steps in copper extraction include:

- Blending of different grades of concentrates;
- Smelting of concentrates in ISASMELT furnace to produce an intermediate copper rich product known as ‘matte’ containing 60-65% copper and eliminate iron as iron silicate (Ferro Sand) by adding silica;
- Converting liquid matte to blister copper (98-99% Cu) in Pierce-Smith converters (PS converters);
- Fire refining of blister copper to produce anode copper (99.5% Cu) in anode furnace and casting of the anodes; and
- Electrolytic refining of anodes to produce copper cathodes (99.99% Cu).

In the process of extraction of copper metal from copper concentrates, sulphuric acid is recovered as a by-product from the sulphur dioxide emanating from the ISASMELT and PS converting furnaces.

1.2 **Brief Process Description - Smelter Plant**

ISASMELT is an established, novel pyro-metallurgical bath smelting process for the extraction of copper from copper concentrates. The process comprises of smelting the copper concentrate in a vertical, cylindrical, refractory brick lined, flat roofed furnace vessel. A central lance injects air, oxygen and fuel into the molten bath of ferro sand and the matte. The oxygen enriched air and fuel down the lance violently stirs the liquid vigorously. These lances are the proprietary supply of the technology supplier. These lances are a ‘pipe within pipe’ assembly. They are constructed from a composite of stainless and mild steel and incorporate specially designed helical gas swivel that enables the use of low-pressure air and oxygen. Controlled swiveling of the process gases inside the lance cools the outer section sufficiently to solidify a layer of ferro sand around the outer surface of the lance. This provides a protective coating in the highly aggressive bath environment.

The lance goes through the top of the furnace into the bath and the SO\(_2\) off-gases from the furnace pass up through an uptake shaft to a waste heat recovery boiler (WHRB) and the gases pass through an electrostatic precipitator for the removal of the dust before the gases are conveyed to the sulphuric acid plant.

The products of the ISASMELT process, matte and ferro sand are tapped periodically from the bottom of the furnace through a water-cooled copper tap
hole. The matte and ferro sand then flow into a Rotary Holding Furnace (RHF) where the matte separates from the ferro sand due to density. The ferro sand from the rotary holding furnace / Ferro sand cleaning furnace is granulated in a dedicated ferro sand granulation system and the granulated ferro sand is discarded to a place inside the smelter plot for beneficial applications.

The matte (63±3% Cu) is conveyed through ladles to Pierce Smith (PS) Converters for conversion to blister copper by blowing process air into the bath through tuyeres. The SO₂ off gases from the PS converter is passed through an ESP for the removal of residual dust before being led to acid plant for the production of sulphuric acid.

The blister copper is further treated in anode furnaces by fire refining and cast into anodes for electro-refining in an ISA REFINERY to a saleable copper cathode of 99.99% Cu purity.

1.2.1 Operational Theory of Smelter

The copper concentrate is selectively oxidized in the bath of the ISASMELT furnace in such a way to liberate part of SO₂ and the exothermic heat from reactions inside the furnace raises the temperature of the constituents above their melting point. The instantaneous smelting reaction forms molten mass of Cu₂S, FeS, FeO and Fe₃O₄. Further reaction takes place in the molten mass where FeO reacts with the silica in the charge to form ferro sand. Two separate liquid phases are formed in the rotary holding furnace.

After the removal of ferro sand by granulation, molten matte from the RHF furnace containing about 63±3% copper is poured from the RHF at about 1200°C into ladles and six ladles of 10m³ are transferred through EOT cranes to the Pierce-Smith converter. In converter, air is blown to the liquid matte at 150 kPa pressure through side-blown tuyeres, and quartz added as a flux in three stages results in production of the blister copper. The operation of converter is autogenous and exothermic; the heat of reactions is more than sufficient to maintain the operating temperatures. The products from converter are blister copper (about 98.5% Cu) and ferro sand (approx. 5-7% Cu).

The ferro sand from the converters is cleaned in a ferro sand cleaning furnace for reducing copper in discard ferro sand. The ferro sand is allowed to settle in ferro sand cleaning furnace where again two layers of molten matte and ferro sand are formed. Matte from ferro sand cleaning furnace is treated in converters whereas ferro sand is granulated and discarded.

The off gases from ISASMELT furnace and converters after cleaning and cooling are utilized for the production of sulphuric acid.

Blister copper poured from converter to ladles is transferred to anode furnaces by means of EOT cranes for further fire refining. Controlled air blow first oxidizes remaining sulphur to remove as sulphur dioxide. However in the process, part of copper is also oxidized, which is reduced back by reduction with hydrocarbons available from cracking of LPG. The fire-refined copper containing about 99.7% Cu is cast on rotating anode casting twin wheel as anodes each weighing about 390kg. The anodes are dispatched to tank house for electro-refining.
1.2.2 Brief Process Description - Electrolytic Refinery

The anodes cast in the smelter section are electro refined in electrolytic cell to produce cathodes based on the process technology developed at CRL, Townsville, Australia by Xstrata Technology, Australia. The process commonly known as ISA process uses permanent stainless steel electrodes as cathodes and copper anodes from Smelter as anodes in the electrolytic cells. Electrolysis of copper anodes is carried out by passing Direct Current from the rectifier. Copper ion from anode dissolves in electrolyte and gets deposited on the stainless steel cathode as sheets. The copper deposits are mechanically stripped from both sides of the stainless steel mother blanks. After stripping the S.S. mother blanks are recycled back to the electrolytic cell for subsequent use. The stripped copper deposits form the 99.99% pure Copper production from Cell house. One anode cycle lasts nearly three weeks and three cathode crops are drawn at weekly intervals.

The anodes after receipt from smelter are unloaded on to the feed conveyor of the anode preparation machine. The machine accepts good anodes and rejects bad anodes on weight basis. The anodes are pressed to straighten and lugs are milled in the machine for ensuring better electrical contacts. Prepared anodes are discharged on to separate spacing conveyors with desired spacing for loading into the electrolytic cells by tank house overhead cranes.

The anodes (57 Nos.) and stainless steel cathodes (56 Nos.) are placed in each electrolytic cell with a pitch of 100 mm, arranged in 40 sections of 30 cells each filled with electrolyte, with a composition of 38-55 gm/liter Cu and 150 - 190 gm/liter H₂SO₄. The electrolysis of copper anode is carried out by applying a current density applied is 313 Amp/m² of cathode surface. The electrolyte in the cells is circulated continuously at 65ºC to facilitate the nodular free uniform deposit of copper on cathode. The electrolyte is pumped from a circulation-collecting tank to an overhead tank through a heat exchanger. From the head tank, the electrolyte flows down under gravity to feed each cell at the rate of 35 liter/minute. The electrolyte enters the cell at bottom and leaves from the top ensuring the flow of the electrolyte throughout the cell. The return from the cells flows to circulation tank, through a mist eliminator. Additive reagents like Gelatine or Glue, Thioare, HCl, etc are added to circulating electrolyte to improve the quality of the cathode deposit. To arrest the floating slime in the electrolyte a polishing filter continuously filters around 30% of the electrolyte in circulation.

The cathodes are harvested on a seven day cycle, constituting three cathode crops out of each anode cycle of 21 days. At the end of each harvest of 7 days, the cathodes are pulled out of the electrolyte cells. During this pulling time the entire block of cells is by passed from the main electrical circuit by means of electrical shunt and switch system. The 56 nos. of cathodes are lifted from the each cell by lifting bail attached to an overhead crane and transported to the cathode-stripping machine. In stripping machine, the cathodes are washed by high-pressure jet water in washing chamber. After washing the cathodes are flexed to release the copper deposits from the SS cathodes (Mother blanks). The deposited copper mass is stripped off from the blanks as copper cathode sheets and stacked one over other. The copper cathode sheets are stacked to a predetermined bundle size; it is further conveyed to next station for weighing.

The stripped mother blanks are advanced to the discharge conveyor and spaced at the desired pitch. The set of mother blanks, each consisting of 56 blanks, are lifted by lifting bail of overhead crane to place into electrolyte cells for start of new cathode cycle.
At the end of anode cycle, the anode scrap weighing around 50 kg each is removed from the cells by over head crane and placed in the feed conveyor of Anode Scrap Washing Machine, for washing of anode slimes from the anode scrap. The washed scrap anodes are recycled back to smelter.

The insoluble part of anodes, which consists of copper and precious metals settle down at the bottom of cells as anode slime during electro refining. After each anode cycle of 20 days, the electrolyte cells are washed with water and the anode slimes are collected in the slime storage tank.

In slime treatment plant, anode slime containing approximately 35% Cu, is treated with sulphuric acid at elevated temperature to reduce copper content. After leaching operation, the copper free slimes are filtered and treated further for separation of nickel, selenium and tellurium. Finally, precious metals, like silver and gold are recovered from the slime as dore metal. From the filtrate, tellurium is precipitated by cementation and tellurium free solution returned to electrolyte purification circuit.

During refining process, copper dissolves in electrolyte and impurities like nickel, arsenic, antimony, bismuth, and selenium etc., also go into the solution. For the production of the good quality cathode the impurities level in electrolyte should be as low as possible and the copper content in the electrolyte required to be maintained at the desired value. This is achieved by withdrawing a small portion of electrolyte from the electrolyte circulation system as a continuous bleed. The electrolyte bleed stream is treated in purification plant where in liberator cells electro winning of copper from electrolyte reduce the copper content. A portion of the treated electrolyte is recycled back to main circulation system and some portion is sent to WWTP for final treatment. During electro winning in liberator cells, arsenic, antimony, bismuth are precipitated and collected as a copper arsenic sludge for disposal.

1.2.3 Brief Process Description - Sulphuric Acid Plant

The sulphur dioxide gases generated during the copper concentrate smelting in ISA and matte converting operation in PS converter of copper smelter plant are treated in sulphuric acid plant for the production of sulphuric acid as a byproduct. The process of production of sulphuric acid consists of three principal steps:

- Cleaning of the sulphur dioxide gas from the ISASMELT furnace and PS converters;
- Catalytic conversion of the sulphur dioxide (SO₂) gas to sulphur trioxide (SO₃) gas according to the chemical reaction:
  \[ \text{SO}_2 + \frac{1}{2} \text{O}_2 \leftrightarrow \text{(SO}_3) \]
- Absorption of the sulphur trioxide (SO₃) gas by reacting with diluted H₂SO₄ to form concentrated sulphuric acid (H₂SO₄).

The conversion of SO₂ to SO₃ is an exothermic, reversible and adiabatic reaction and with increase in temperature the equilibrium constants become more unfavorable with respect to SO₃ formations. The other factors, which favour equilibrium conversions, are increase in oxygen concentration in the gases and or high pressures but the relative gains are rather small. In contrast to the unfavorable effect of high temperature on equilibrium it is found that the rate of reaction increases rapidly with rising temperature. Consequently, optimum
performance requires a balance between the opposing effects of reaction rate and equilibrium. Thus, the gases entering the V₂O₅ catalyst normally are maintained between 400 - 450ºC. Therefore, in order to achieve over-all high conversion efficiencies between 99.6% - 99.7%, it is imperative that the converter gases need to be cooled between stages to the above temperature range and also removing the partially converted sulphur trioxide formed normally after 2nd/3rd beds, before returning them to subsequent stages. This process is commonly known as Double Conversion and Double Absorption (DCDA).

1.2.3.1 Purification of SO₂ Gas

The SO₂ gas from the smelter and PS converters contains metallic dust, fume, acid mist, water vapour and various other impurities like halides etc., which are not only detrimental to the catalyst used for conversion in the sulphuric acid production but also contaminate the product. The gases are therefore cooled, cleaned in the gas cleaning plant comprising of gas cooling tower, Dynawave Scrubbing System and wet electrostatic precipitators. A portion of the weak acid from circulation system of the scrubbers is continuously bled, which is predominately consists of the halides like, fluoride, chlorides etc., to the Wastewater treatment plant. The wet gas precipitator electrically removes the acid mists formed during the downstream operations and optically fully saturated SO₂ bearing gases are conveyed to the sulphuric acid plant.

1.2.3.2 Drying, Conversion and Absorption of SO₂ to SO₃

The optically cleaned SO₂ rich gases along with dilution air to the extent required for maintaining the requisite O₂ /SO₂ ratio are dried in a drying tower with 96% concentrated sulphuric acid in counter current circulation. The dried gases after heating to 400-450 ºC passed through converter with cesium promoted vanadium pentoxide catalyst. The converted SO₃ gases are absorbed in two absorption towers where 98% concentrated sulphuric acid is circulated to produce 98.5% strength Sulphuric acid product.

CESIUM CATALYST AND XLP RING DESIGN

MECS provides guarantee on SO₂ conversion through its highly active, low pressure drop catalyst. MECS XLP catalyst reduces pressure drop compared to ring type catalyst used in the same converter. Because of this, in a new plant the pressure drop can be reduced significantly. This ring type design is also used for Cesium catalyst, which was first patented by MECS in the 1960s. Cesium lowers the temperature at which initial conversion takes place, allowing MECS to guarantee ultra-high levels of SO₂ conversion (>99.9%) without the use of a tailgas scrubber.

1.2.4 Brief Process Description – Phosphoric Acid Plant

The production of phosphoric acid is based on well known Hemihydrate Dihydrate process. The main raw materials for the phosphoric acid production are rock phosphate and sulphuric acid. The rock phosphate is reacted with sulphuric acid in a series of reactors to produce phosphoric acid. The solid waste (phosphogypsum) generated in the process is separated and transferred to the low / high density polyethylene lined gypsum pond through pipe conveyers. The off gas from the reaction containing hydrogen fluoride is scrubbed and converted to hydro fluoro silicic acid, which is sold as a byproduct.
1.3 **Plant Facilities**

The major technological units envisaged for the copper smelter plant are as given below:

- Raw Material Handling System;
- Isasmelt Smelting;
- Converting;
- Ferro sand Cleaning and Disposal;
- Anode Refining and Casting;
- Electrolytic Refining;
- Continuous Copper Rod;
- Sulphuric Acid Plant;
- Phosphoric Acid Plant; and
- Oxygen Plant.

1.3.1 **Raw Material Handling System**

Copper concentrate and rock phosphate will be imported from various sources at Thoothukudi port through shipment. These materials will be transferred into warehouse by tippers / wagons. The Copper Concentrate and the rock phosphate will be stored in separate warehouses. Similarly, other raw materials (fluxes) required for smelting viz. silica, limestone and quartz, will be procured from indigenous sources and stored in the raw material storage area, outside the warehouse.

1.3.2 **ISA Smelting**

The process for the smelting of copper from the copper concentrate by ISASMELT process, which is a proprietary technology of M/s Xstrata Technologies, Australia. The process flow diagram of ISA smelter and Rotary furnace is shown in Figure-1.1.
FIGURE 1.1
PICTORIAL DIAGRAM OF ISA SMELTER AND ROTARY FURNACE
The ISA smelting comprises of the following main facilities:

- Furnace Building;
- Furnace Raw Material Feed System;
- The Smelting Furnace;
- The Lance Handling And Services System;
- Molten Matte/ Ferro sand Handling System;
- Off Gas Handling System;
- Waste Heat Recovery Boiler System;
- Super Heater System in Sulphuric acid plant WHRB;
- Turbine Generator System;
- Air Cooled Condensers;
- Cooling Water System; and
- Hygiene Ventilation System.

1.3.2.1 Molten Matte/ Ferro sand Handling System

The furnace matte/ ferro sand is periodically tapped from the tap hole, which is provided with water cooled copper block. The tap hole is opened by a tap-gunning machine. The ferro sand/ matte together flow by gravity to the Rotary Holding Furnace (RHF) for ferro sand and matte settling and separation. The operation is being carried out in a horizontal cylindrical furnace MS shell lined with refractory. It is fired by Oxy-fuel burner to maintain the operating temperature of around 1200ºC. The off-gases are passed through a venturi before being led to the common hygiene ventilation system for scrubbing.

Ferro sand settled in the Rotary Holding Furnace (RHF) is being granulated separately in a dedicated launder system and is collected in the collection pond. Ferro sand granulation water overflows into a water pond, cooled in a spray pond and recycled to the nozzles of the granulation launders.

1.3.2.2 Off-Gas Handling System and WHRB System

The ISASMELT furnace is maintained under negative pressure at all times to ensure proper capturing of hot process SO₂ bearing off –gases and these gases are utilized for the recovery of the sulphur content as saleable byproduct of sulphuric acid.

The hot SO₂ gases from the ISASMELT furnace, before being led to the sulphuric acid plant passes through a waste heat recovery boiler (WHRB) to recover the heat to produce approximately 75 t/h of fully saturated steam at 77 bar a. The WHRB has a radiant section and a set of convection bank pendant tubes. The steam produced in the WHRB of ISASMELT is utilized to produce 7 MW of power in a condensing steam turbine set. The excess steam produced is utilized for process requirements.

A major content of the dust carried over in the off-gases is recovered underneath the WHRB through an air cooled drag chain conveyor and fed to a crusher together with the ESP dust for grinding to a size fraction suitable for pneumatic conveying to the recycle bin located in the day bin Building.

Off gases from the waste heat boiler gets cooled to a temperature of 350ºC and are further conveyed to a hot ESP having dust collection efficiency to achieve a dust content of approximately 100mg/Nm³. To maintain the manometric balance for the downstream equipment described above and maintain a negative suction pressure at the ISASMELT furnace inlet; an intermediate fan (ID fan) having a
capacity of 120,000 Nm³/hr is provided after the hot ESP. The ID fan further delivers the off-gas to the gas cleaning section of the sulphuric acid plant for cooling and removal of the harmful impurities like fluorine, chlorine, arsenic etc before being sent to sulphuric acid plant for manufacture of sulphuric acid.

1.3.2.3 Hygiene Ventilation System

A provision has also been kept to collect secondary gases arising from ISA and RHF operations and is being treated in Hygiene Ventilation System having capacity of 362000 NM³/hr.

The Secondary emissions from ISA and RHF (such as the feed port, tapping port) are captured through hood arrangements and are scrubbed in the ISA/RHF Hygiene Ventilation Systems (HVS). The HVS consists of venturi scrubbers and demister arrangements. Milk of Lime is used as a reagent for scrubbing the secondary gases. The scrubbed gases, free of SO₂ except for some traces are vented through a stack.

1.3.3 Converting using PS Converter

1.3.3.1 Raw Material Feeding System

Crushed revert and quartz (SiO₂ - 90% to the size of 20 - 25 mm) are fed to the converters during the operation. Two sets of bins consisting of two bins each (one for quartz and one for revert) exists for converters. These bins are filled by a common conveyor system.

Materials from these bins are reclaimed by vibro-feeders located below the bunkers and the reclaimed material is fed to the Converters.

PS Converter charging system is provided with dust extraction system (ESP) to prevent escape of dust to the atmosphere.

1.3.3.2 P.S. Converter

Molten matte tapped from the rotary holding furnace (RHF) in 10 m³ ladles is transferred to Pierce-Smith converter with the help of an E.O.T. crane. 4 Nos. of Cranes having capacity of (80 tonnes). Four converters (3 hot + 1stand by) exist with two converters in operation at a time.

During converting operation, air under pressure is passed through the specially designed tuyeres into the molten bath. The air oxidizes the matte to form ferro sand and blister copper. Crushed quartz (20-25 mm size) is added as flux in the converter. Quartz is being stored in a hopper located centrally between two converters. Weighed quantity of quartz is delivered to converter through weigh feeders. The converting process is a batch operation taking about 5.0 hours for producing 125 tonnes of blister copper in each cycle. The blister copper is transferred for further processing in the anode furnaces through dedicated blister copper ladles having a capacity of 7-m³ each.

Ferro sand with 7 to 10% copper is tapped intermittently into ladles having a capacity of 10-m³ and recycled to rotary Ferro Sand cleaning furnace for recovery of contained copper content into matte and fixation of iron as ferro sand.
Converter off-gases at 1200°C are collected in double hood system. The converter hoods are in two sections; water cooled primary hood through which process SO$_2$ off gases are collected having a capacity of 2,40,000 Nm$^3$/hr gas handling capacity and secondary hood through which secondary gases are collected.

The gases then passes through an electrostatic precipitator (ESP) with a capacity of handling 240,000 Nm$^3$/hr gas flow, to minimize dust carry-over to the sulphuric acid plant. Dust collected from off gases in ESP is recycled to ISASMELT furnace through a pneumatic conveying to the recycle bin located in the day bin Building. Converter SO$_2$ off-gases are finally sucked by I.D fans and delivered to Mixing chamber where they mix with ISASMELT furnace gases and utilized for sulphuric acid production.

The secondary off-gases from the secondary hoods are conveyed to secondary scrubber having capacity of 470,000 Nm$^3$/hr.

1.3.4 Ferro sand Cleaning and Disposal System

1.3.4.1 Ferro sand cleaning Furnace Charging System

The coke and quartz are the main raw material required during process operation. A small quantity of the pig iron is charged using the shop EOT crane into a charging bin.

1.3.4.2 Ferro sand cleaning Furnace

Ferro sand from PS converter furnaces are transferred to the rotary ferro sand cleaning furnace by ladles with the help of EOT crane. The ferro sand is allowed to settle in the furnace (settling time around 1.25 hrs) where copper in ferro sand settles down and forms a layer of matte. Ferro sand from Ferro sand cleaning furnace is water granulated in a dedicated ferro sand granulation system having a capacity of 400 tpd. Matte (65% Copper) from Ferro sand cleaning furnace are tapped and charged back to the PS converters.

The Ferro sand cleaning furnace consists of steel construction with refractory lining mounted on roller cradles. Oxy-fuel burners are envisaged for heating and maintaining the ferro sand & matte under molten condition. The off-gases generated during Ferro sand cleaning furnace operations are cooled to 350°C before being led to the common hygiene ventilation system for scrubbing before discharge to the atmosphere.

1.4.4.3 Ferro sand Disposal System

Ferro sand generated in the Ferro sand cleaning furnace is granulated separately in a dedicated launder system and is collected in the collection pond. Ferro sand granulation water overflows into a water pond, cooled in a spray pond and recycled to the nozzles of the granulation launders.

The granulated ferro sand settling pond is provided with a grab crane of 30 tonnes capacity which collects the ferro sand from the pond and discharges the same in a steel bunker. The ferro sand from the steel bunkers is unloaded into the outsourced tippler truck dumper and transported to the designated ferro sand yard within the plant boundary for storage and further sale/ disposal.
1.3.5 **Anode Refining and Casting**

Three number of anode furnaces are used for refining of blister copper to anode copper. Anode furnaces are provided with LPG & Oil burners. Blister copper is received in anode furnaces through ladles (7m³) with the help of EOT crane. Blister copper is first slowly oxidized to remove dissolved sulphur below 50 PPM by blowing air in it through tuyeres. The metal is subsequently reduced by use of LPG to control Oxygen around 1,500 PPM.

Fire-refined copper is cast into anodes (approx. 390 kg each) on rotating twin / single wheel casting machine having a capacity of 110 t/h by means of automatic anode weighing and casting device. Anodes from cast wheel is lifted by means of an automatic take-off device, cooled and stacked on a conveyor for onward conveying to the anodes preparation yard.

Hot off-gases from the anode furnaces are drawn by exhaust fan, scrubbed through hygiene ventilation scrubbing (HVS) before discharge to the atmosphere.

1.3.6 **Electrolytic Refinery**

Electrolytic refinery has two independent units namely;

- Tank house; and
- Purification plant.

The process flow diagram of electrolytic refinery is shown in **Figure-1.2(A)**.

The technological facilities in Tank House comprise the following:

- Anode preparation facility;
- Production cells;
- Electrolytic circulation system;
- Filtration of electrolyte;
- Additive dosing facility;
- Electrolyte storage;
- Fume extraction;
- Cathode stripping facility;
- Anode scrap washing facility;
- Extraction of slime;
- Thickener; and
- Thickener-overflow

The technological facilities in the purification plant comprises of following:

- Control cells;
- Liberator cells;
- Slime treatment facility; and
- Fume extraction.

Besides, other major facilities like overhead cranes, rectifiers, bus-bar system, instrumentation and general services exists to meet the requirement of tank house and purification plant.

The copper anodes containing about 99.5% to 99.7% copper is electrolytically refined to about 99.99% purity which is necessary to obtain the required electrical conductivity for electrical applications.
The impure anodes contain around 99.5% to 99.7% copper, 0.15% oxygen and traces of other impurities such as precious metals. Anodes and stainless steel cathode plates are suspended alternatively (56 anodes and 55 cathodes) in the electrolysis cell. The electrolytic cells are connected in series to form one bank. A bank can be electrically isolated from others for the purpose of changing anodes and stripping by using short circuit switches. The current passes from cell to cell via intermediate busbars. Direct current required for electrolysis is provided by rectifier. From rectifier current flows through bus bars to banks and provides power for electrolysis.

The electrolytic cells are filled with electrolyte (copper sulphate, sulphuric acid, water and anode impurities). The electrolyte, which flows through cell, is preheated and circulated. The temperature of electrolyte is maintained at 63° C to 65° C and flow is maintained at 25-35 liters per minute per cell. During circulation of electrolyte, other reagents (Glue, Thiourea and hydrochloric acid) are added to achieve smooth fine-grained deposit. Electrolysis is conducted for about five to seven days (this time can be varied according to the current density).
FIGURE-1.2 (A)
FLOW DIAGRAM OF ELECTROLYTIC REFINERY PROCESS
Copper is electrochemically dissolved from the anodes and gets deposited on the cathode, at a rate depending upon the strength of the current. The copper deposited cathode plates are removed from the electrolytic cells and are passed through cathode stripping machine, where cathodes are washed and copper is stripped from cathodes plates. The copper is bundled, weighed and strapped ready for use in Continuous Copper Rod Plant (CCR) or dispatched to customers. The mother banks return to the process for further deposition.

The undissolved part of anode, called anode scrap is washed free of electrolyte in Anode Scrap Washing Machine (ASWM) and is recycled back to smelter for remelting as anodes. The insoluble impurities (anode slimes) which settle at the bottom of the cell are collected and subjected to leaching process, where copper is removed from the slime. The leached slime is then filtered, dried and processed further.

During Electro-refining, some anode impurities (noble metals and heavy metals) gets dissolved in electrolyte. The build-up of concentration of these impurities in electrolyte solution affects the electrolysis process and results in poor quality of cathode. The concentration of such impurities in the electrolyte is controlled by bleeding off some quantity of electrolyte and making-up with fresh electrolyte solution.

1.3.7 CCR Plant

The CCR plant (Continuous Rod Plant) converts Copper Cathodes into rods by melting and rolling. Copper cathodes contain around 99.99 plus % copper and is one of the purest forms of commercially available copper. Their copper cathodes are to be processed and made into rods of varying sizes to make them amenable for wire drawing. A brief description of the process is as under:

1.3.7.1 Technology

Our technology supplier for copper rod plant is "Continuous Properzi" Italy.

1.3.7.2 Main Raw Material feed

The raw material for the process is Copper Cathode of LME (London Metal Exchange) Grade A Quality. These cathodes along with pure in-process scrap from rod plant are used for melting. Cathodes are made into bundles and charged into a Shaft furnace with the help of a Skip hoist.

1.3.7.3 Shaft/Melting Furnace

The shaft furnace has LPG / Propane fired nozzle mix burners at the bottom to melt cathode at a temperature of 1100°C and this melting temperature is controlled by a computer controlled system. The flame from the burner hits the cathodes and melts the same. Since there are column of Cathodes above the burners, the hot gases pass through the cathodes and transfers sensible heat to the descending charge thus increasing thermal efficiency. The fuel used is free from sulphur as Propane or LPG is used. Consequently there is no pollution of any nature because of Shaft furnace.

One specialty of the furnace is that there is no molten metal in the furnace and the metal as it melts freely flows out and the temperature is kept very low to prevent hydrogen pick up. The molten metal flows through covered Launders at a temperature of 1100°C to a Holding furnace.
1.3.7.4 Holding Furnace and launder system

The holding furnace acts as buffer between melting and "continuous properzi" copper wire rod-making machine. The holding furnace is heated at a temperature of 1100°C using Propane / LPG. The same fuel heats the launders. The temperature is kept as low as possible to prevent over oxidation and pick up of Hydrogen.

1.3.7.5 Copper Wire Rod Making Machine - "Continuous Properzi"

**Copper Bar Preparation Unit**

The molten metal from the Holding furnace is transferred to the Tundish through the premix burner fired Launders, whose level is automatically controlled. The Tundish then feeds the metal into a rotating wheel (trapezoidal groove) from one side. Here the metal gets solidified as the wheel cooled with water jet sprays. Solidified hot cast bar comes out of the wheel and passes through automatic shearing machine, cast bar straightener & shaving machine. Here the upper edges are shaved to remove the surface copper oxide scales.

**Rolling Mill**

The copper bar then enters the Rolling mill at about 850°C. Here it passes through Roughing mill, Intermediate mill and Finishing mill. The cross section is reduced in 11 stages with intermediate sections of triangles & circles to reach the required diameter of rods.

**Pickling and Quenching**

The rod exiting from the rolling mill is passed through Pickling unit (2% IPA solution in water and emulsion mixture) in order to reduce the Surface oxide of the rod. After the pickling the rod is quenched in water to reduce the temperature from 500°C to 60°C.

**Drying and Waxing**

The quenched rod is then dried with compressed air in the Drier unit to remove the water droplets from the rod surface. In the waxing unit, a water-soluble wax is sprayed on the rod to protect the rod surface from tarnishing.

**Coiling and Packing**

Wax-coated rod passes through loop forming pipe to form orbital coils of 1.6-m diameter. These coils are produced in 2.2 & 3m weights as per the customer requirement. The rods are then compacted, strapped and stretch wrapped with HDPE Woven cut sheet for dispatch.

1.3.7.6 Wastewater

The only Wastewater generated in the process is the emulsion containing 5 % soluble oil. Discarding of emulsion is after 6 months depending upon roll life of the mill. The soluble oil is sold as secondary oil.

The gases from the Shaft Furnace do not contain any sulphur since the fuel (LPG) used is free of sulphur. The NOx content is negligible since combustion is at a very low temperature. There is no SPM as no soot formation takes place and the metal being melted is only a pure sold copper cathode.
The process flow diagram of CCR plant is shown in Figure-1.2(B).

**FIGURE-1.2 (B)**
FLOW DIAGRAM OF CONTINUOUS COPPER ROD PLANT PROCESS

### 1.3.8 Sulphuric Acid Plant

The sulphuric acid plant has following facilities.

- Purification of off-gases in Gas Cleaning Plant;
- Conversion of SO\(_2\) to SO\(_3\) in contact section by DCDA process;
- Production of sulphuric acid in absorption section;
- Waste heat recovery section;
- Acid circulation system;
- Product storage & tanker loading facilities; and
- Tail gas scrubbing facilities.

The process flow diagram of gas cleaning plant and sulphuric acid plant are shown in Figure-1.3 and Figure-1.4 respectively.

#### 1.3.8.1 Purification of off- gases in Gas Cleaning Plant

The partially cooled and clean gas from the primary gas handling system containing 11% to 12% SO\(_2\) is processed in SAP to produce sulphuric acid. The gas from the primary gas handling system is cleaned and condensed in a primary quencher vessel and a retention vessel. These units provide quenching of the hot gas to the saturation temperature and provide retention time for particle condensation and coalescence. In addition to the removal of coarser dust particles, these units, also absorb hydrogen chloride and hydrogen fluoride vapors present in the gas, if any.
The saturated partially cleaned gas, then enter the Venturi Scrubbers where sub-
micron particles are captured and removed from the gas. The dust free gases are
further cooled in cooling towers and cleaned in wet ESPs for removal of traces of
fine particulates if any. The clean gas is next processed in SAP for production of
sulphuric acid.

1.3.8.2 Conversion of SO\textsubscript{2} to SO\textsubscript{3} in Contact Section and Production of H\textsubscript{2}SO\textsubscript{4} in
Absorption Section

The gas from the Gas Cleaning section, saturated with water at 350\textdegree C, is drawn
into the Drying Tower under suction from the main blower. Dilution air if required
is added at this point to regulate the concentration of SO\textsubscript{2} in the gas entering the
Converter. The gas is dried by counter-current contact with a stream of 93% acid
in the drying tower. Acid mist carryover in the gas stream from the drying tower
is reduced by means of a mist eliminator located at the top of the tower. The dry
gas from the drying tower is compressed in the main blower. The compressed gas
is further heated to a temperature of 410\textdegree C in the heat exchangers before it
contacts the catalyst (vanadium pentoxide) in the converter. The converter has 4
beds of catalyst. The catalyst beds not only facilitate the conversion of SO\textsubscript{2} to
SO\textsubscript{3}, but also controls the increase in gas temperature due to exothermic
conversion of SO\textsubscript{2} to SO\textsubscript{3}. The gas from the second converter bed where
approximately 94% of the SO\textsubscript{2} gets converted to SO\textsubscript{3}, is absorbed in 98.5%
Sulphuric acid in the Intermediate Absorption Tower. Acid mist carryover is
reduced by passing the gas through candle type mist eliminators. The gas from
the intermediate absorption tower is again processed in 3\textsuperscript{rd} and 4\textsuperscript{th}
converter bed where overall conversion of remaining SO\textsubscript{2} to SO\textsubscript{3} takes place. The gas from the
4\textsuperscript{th} converter bed is again absorbed in 98.5% sulphuric acid in the Final
Absorption Tower to produce sulphuric acid of desired strength. The produced
acid is stored in storage tanks. Acid mist carryover is reduced through the use of
Brownian Diffusion candle type mist eliminators. The gas leaving the Final
Absorption Tower is discharged to atmosphere via Stack.

1.3.8.3 Waste Heat Recovery Section

In waste heat recovery system, the DM water is heated in economizer and low-
pressure boiler by recovering heat from heat generated during conversion of SO\textsubscript{2}
to SO\textsubscript{3} in converters to produce super-heated steam in SAP.

1.3.8.4 Product Storage

The 98.5% sulphuric acid produced is pumped from the product tank. The
product acid from the storage tank is loaded in acid tankers for dispatch.
FIGURE-1.3
PICTORIAL DIAGRAM OF GAS CLEANING PLANT

Drying Tower (DT)
Gas from GCP
Blower
Waste Heat Recovery Boiler

Converter Bed
2
3
4
1
Intermediate Absorption Tower
Final Absorption Tower
98.5 % H2SO4
Product

Air Cooler
ATPT
Acid Cool
DM Water
Stack

FIGURE-1.4
PROCESS FLOW DIAGRAM OF SULPHURIC ACID PLANT
1.3.9 **Phosphoric Acid Plant**

In order to balance the generation and the demand of sulphuric acid, a part of sulphuric acid is captively utilized for production of phosphoric acid.

The main raw materials for the phosphoric acid production are rock phosphate and sulphuric acid. The rock phosphate is reacted with sulphuric acid in a series of reactors to produce phosphoric acid. The concentration units are equipped with a fluorine recovery plant which produces 80 MTPD of hydrofluosilicic acid as 100% H$_2$SiF$_6$. The plant is equipped with an efficient scrubbing system to meet stringent environmental standards. The following steps are involved in the manufacturing process:

- Rock Handling;
- Reaction;
- Hemi-hydrate filtration;
- Transformation;
- Di-hydrate filtration;
- Concentration; and
- Acid storage.

**1.3.9.1 Rock Handling**

Rock phosphate is unloaded at Tuticorin port and brought to site by road or by rail and the rock is unloaded into the silo by means of unloading conveyors. Shovel loaders are used to feed the material to the reclaim hopper, from where the rock is conveyed to the main plant. Rock dust, which emanates from the system is collected, scrubbed with water and sent back to the first reactor.

**1.3.9.2 Reaction**

There are three agitated reactors in series operation. The reactors are of mild steel with 10 mm thick butyl rubber lining followed by carbon brick lining in three layers. The rock phosphate and recirculated acid slurry from the flash cooler are fed to reactor 1A. 40% of the calcium fed to Reactor 1A is precipitated in Reactors 1A and 1B. Slurry from Reactor 1A overflows to Reactor 1B and finally enters Reactor 2. In Reactor 2, 98.5% H$_2$SO$_4$ and 36% P$_2$O$_5$ acid are added with the slurry and the remaining calcium in solution is precipitated. The system temperature is maintained at 98-100$^0$ by means of a flash cooling system through which the slurry is pumped from the Reactor 2 to the Reactor 1B. The off gases evolved during reaction and during flash cooling are being scrubbed in reactor off gas unit and in Flash cooler off gas unit respectively. Scrubbing is done with water and hydrofluosilicic acid is produced at a concentration of 18% which is filtered in a silica filter to remove the silica content and the filtered acid is sent for storage.

**1.3.9.3 Hemi Hydrate Filtration**

This comprises of a horizontal belt filter and the slurry from the flash cooler is fed to the filter and washed counter currently. The acid collected from the first filtrate is product acid of 43% P$_2$O$_5$. Second filtrate is return acid of 36% P$_2$O$_5$ which is pumped back to the third reactor. Before the cake is discharged to the first transformation tank, final washing is done by 9% P$_2$O$_5$ acid from the dihydrate filter. A vacuum up to 0.25 bar is maintained by operating two centrifugal vacuum pumps.
1.3.9.4 Transformation

There are two transformation tanks, made up of mild steel, rubber lined and carbon brick lined, operating in series. An agitator is mounted for better mixing and keeping the slurry in suspension. Hemihydrate cake HH cloth wash liquor and Sulphuric acid are added to tank No. 1 and it overflows to tank No. 2. The residence time is sufficient to achieve conversion of Hemihydrate to dihydrate under controlled conditions and the slurry is then fed to the dihydrate filter.

1.3.9.5 Di-hydrate Filtration

This comprises of a horizontal belt filter and the slurry from the transformation tank is pumped to the filter and it is washed counter currently. The cake undergoes two washings before it is discharged to the gypsum slurry tank. The first filtrate of 9% P₂O₅ is used as final wash for the hemi-hydrate cake. The second filtrate is used for washing the hemi-hydrate filter cloth.

The gypsum generated is transported to gypsum pond through pipe conveyors to avoid spillage.

1.3.9.6 Concentration

The product acid of 43% P₂O₅ from the hemihydrate filter is further concentrated to obtain 54% P₂O₅ in the concentration section. Acid from the hemi-hydrate filter is pumped to the clarifier for removing the solids present before it is pumped to the concentrator. The clarifier is a mild steel rubber lined vessel and acid brick lined at the conical bottom portion. There are two clarifiers, one at the inlet of the concentrator. A centrally mounted rake mechanism is used for removing the sludge from the acid. The clear acid from the clarifier top is pumped to the concentrator and the sludge from the clarifier bottom is pumped back to the third reactor for recovering the entrapped P₂O₅. There are two concentrators operating in parallel with the fluorine recovery unit. The concentrator is a mild steel rubber lined cylindrical vessel with a conical bottom. A graphite heat exchanger is used to raise the acid temperature to 85°C by means of a low pressure steam (1.5 Kg/cm²). The steam is generated from "Smoke Tube" type Boilers. Acid circulation between the concentrator and the graphite heat exchanger is done by an axial flow pump of high volume and low head. The concentrated acid overflows from the concentrator (flash chamber) to a concentrated acid seal tank and is pumped to the concentrated acid clarifier through three acid coolers. The clarified acid is then pumped to the acid storage tanks. The non-condensable are removed by a vacuum jet system consisting of 2 steam jet ejectors operating on 10 Kg/cm² steam and an inter condenser operating on cooling water. The ejectors maintain a vacuum of 53 mm Hg (abs.) The gases evolved during concentration are scrubbed in fluorine scrubbing system and the hydrofluosilicic acid (18%) is sent for storage.

1.3.10 Cryogenic Oxygen Plant

Oxygen is required for ISASMELT furnaces continuously and PS converters occasionally, for FSCF & RHF Oxy-Fuel burners intermittently.

These oxygen plants consist of main air compressors running simultaneously. The plant produces oxygen (95% purity) and nitrogen (99.9% purity). Argon production is not considered, since argon is not required. Liquid storage for LOX is provided.
1.4 Plant Layout

Copper Smelter Plant - II will be located in the SIPCOT Industrial Complex, Therkku Veerapandia Puram Village, Thoothukudi. The Total area earmarked is 128.805 Hectare of land allotted by State Industries Promotion Corporation of Tamil Nadu Limited, (SIPCOT), Government of Tamilnadu.

State Industries Promotion Corporation of Tamil Nadu Limited ('SIPCOT') handed over land of 131.3 ha for 1200 TPD copper smelter Plant - II. SIPCOT and executed three lease deeds, one, dated 16-02-2009 (for 36.16 hectares of land), the second, dated 07-10-2009 (for 93.33 hectares of land) and the third dated 03-06-2010 (for 1.84 hectares) in favour of the Company at SIPCOT Industrial Complex, Thoothukudi and handed over the land as per lease agreements to the Company.

At present, we have 233.7 ha of land in total. Copper Smelter- I is located in 102.31 Ha. area, Copper Smelter –II will be located in 128.805 ha. and the Land kept in hand in Zone –A for future purpose is 2.585 ha.

Green Belt:

We have developed Green Belt around the Copper Smelter Plant-II boundary as per the TNPCB direction. We have till date developed 43 Ha of greenbelt in the total area earmarked for the existing and the proposed project site. After the Copper Smelter Plant–II project execution, our total green belt area will become 72.35 hectare as per the environmental clearance issued on 01.01.2009 in and around the existing Copper Smelter Plant-I, Copper Smelter Plant-II and Tamira-I (Employees Quarters) and railway siding area.
FIGURE-1.5
OVERALL PLANT LAY OUT
FIGURE 1.6
PROCESS FLOW DIAGRAM OF COPPER SMELTER PLANT – II
1.5 Proposed Copper Smelter Plant –II -

Copper Smelter Plant –II is designed for the capacity of 1200 TPD of copper anodes production. The major design parameter of proposed copper smelter is presented in Table-1.1. The process flow diagram of the proposed copper smelter is shown in Figure-1.6.

**Table-1.1**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Proposed Capacity</td>
<td>1200 TPD Copper Anodes</td>
</tr>
<tr>
<td>2</td>
<td>Concentrate requirement</td>
<td>5061 TPD</td>
</tr>
<tr>
<td>3</td>
<td>Silica requirement</td>
<td>789 TPD</td>
</tr>
<tr>
<td>4</td>
<td>Quartz requirement</td>
<td>173 TPD</td>
</tr>
<tr>
<td>5</td>
<td>Operating days in a year</td>
<td>348</td>
</tr>
</tbody>
</table>

1.5.1 Raw Material Handling

A new concentrate warehouse is proposed for storage of copper concentrate. Subsequently, increase in the unloading conveyors and tipper car will be done. Also, additional feed hopper arrangement will be provided.

1.5.2 Smelting Furnace

It is proposed to have new ISA furnace of 196 TPH for 1200 TPD of copper anode production. The design detail of the proposed ISA smelter furnace is given in Table-1.2.

**Table-1.2**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Design Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concentrate charged</td>
<td>196 t/hr (dry)</td>
</tr>
<tr>
<td>2</td>
<td>Flux Charged</td>
<td>32 t/hr</td>
</tr>
<tr>
<td>3</td>
<td>Matte produced</td>
<td>91t/hr</td>
</tr>
<tr>
<td>4</td>
<td>Matte grade</td>
<td>63% Cu</td>
</tr>
<tr>
<td>5</td>
<td>Matte temperature</td>
<td>1180-1220oC</td>
</tr>
<tr>
<td>6</td>
<td>Slag Produced</td>
<td>112 t/hr</td>
</tr>
<tr>
<td>7</td>
<td>Cu in slag</td>
<td>0.5 %</td>
</tr>
<tr>
<td>8</td>
<td>Slag temperature</td>
<td>1180-1220oC</td>
</tr>
<tr>
<td>9</td>
<td>Tapping frequency of ISA furnace</td>
<td>0.5 hr</td>
</tr>
<tr>
<td>10</td>
<td>Gas Volume at furnace outlet</td>
<td>100,800 m3/hr</td>
</tr>
<tr>
<td>11</td>
<td>SO2 % in furnace off gas</td>
<td>35.6%</td>
</tr>
<tr>
<td>12</td>
<td>Gas temperature</td>
<td>1200oC</td>
</tr>
<tr>
<td>13</td>
<td>Process air required</td>
<td>6300 Nm3/hr</td>
</tr>
</tbody>
</table>
1.5.3 **Rotary Holding Furnace and Ferro Sand Cleaning Furnace (RHF & FSCF)**

Rotary Holding Furnaces (RHF) is provided for Ferrosand and Matte separation.

The furnace matte/ferro sand from ISA furnace will be periodically tapped from the tap hole which will be provided with water cooled copper block. The tap hole will be opened with a tap gunning machine. The ferro sand/ matte together will flow by gravity to the Rotary Holding Furnace for ferro sand and matte settling and separation. The temperature around 1260°C will be maintained. The off-gases from the furnace operation will be taken to the proposed ISA hygiene ventilation system for scrubbing.

Ferro sand settled in the Rotary Holding Furnace will be granulated separately in a dedicated laundre system having a capacity of 150 tph and will be collected in the collection pond. Ferro sand granulation water will overflow into a water pond, cooled in a cooling tower and recycled to the nozzles of the granulation launders.

For ferro sand granulation system for Rotary Holing furnace, water circulation system of 1500 m³/hr for the ferro sand granulation system will be provided.

The granulated ferro sand-settling pond will be provided with a grab crane of 30 tonne capacity, which will collect the ferro sand from the pond and discharges the same in a steel bunker. It is envisaged that the ferro sand from the steel bunkers will be unloaded into the outsourced tippler truck dumper and transported to the designed ferro sand dump area within the plant boundary storage and further sale/disposal. The design details of the Rotary Holding Furnace are given **Table-1.3.**

The ferro sand from the converters is cleaned in a ferro sand cleaning furnace for reducing copper in discard ferro sand. The ferro sand is allowed to settle in ferro sand cleaning furnace where again two layers of molten matte and ferro sand are formed. Matte from ferro sand cleaning furnace is treated in converters whereas ferro sand is tapped, granulated and discarded.

**TABLE-1.3**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Design Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ferro sand density</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>Matte charged</td>
<td>2x550 MT</td>
</tr>
<tr>
<td>3</td>
<td>Matte grade</td>
<td>63%</td>
</tr>
<tr>
<td>4</td>
<td>Matte density</td>
<td>4.69</td>
</tr>
<tr>
<td>5</td>
<td>Matte tapping</td>
<td>Intermittent depending on the level</td>
</tr>
</tbody>
</table>
DETAILS OF ROTARY FERRO SAND CLEANING FURNACE

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Design Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ferro sand density</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>Matte charged</td>
<td>2 X 270 MT</td>
</tr>
<tr>
<td>3</td>
<td>Matte grade</td>
<td>64%</td>
</tr>
<tr>
<td>4</td>
<td>Matte density</td>
<td>4.69</td>
</tr>
<tr>
<td>5</td>
<td>Matte tapping</td>
<td>Intermittent depending on the level</td>
</tr>
</tbody>
</table>

1.5.4 Converter

Four converters are proposed for the Copper Smelter Plant - II. The design specification of the pierce-smith converters (4 Nos.) is given in Table-1.4.

TABLE-1.4
DETAILS OF PIERCE –SMITH CONVERTER

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Matte treated per charge</td>
<td>210 tonnes</td>
</tr>
<tr>
<td>2</td>
<td>Matte grade</td>
<td>63% Cu</td>
</tr>
<tr>
<td>3</td>
<td>Blister copper (98.5% Cu) per charge</td>
<td>150 tonnes</td>
</tr>
<tr>
<td>4</td>
<td>Converter ferro sand (7-10% Cu) per charge</td>
<td>46 tonnes</td>
</tr>
<tr>
<td>5</td>
<td>Ferro sand temperature</td>
<td>1220 ºC</td>
</tr>
<tr>
<td>6</td>
<td>Average blow time</td>
<td>5.25 hrs.</td>
</tr>
<tr>
<td>7</td>
<td>Average process air flow</td>
<td>61,100 Nm3/hr</td>
</tr>
<tr>
<td>8</td>
<td>Quartz per charge</td>
<td>20 tonnes</td>
</tr>
</tbody>
</table>

1.5.5 Anode Furnace and Cast Wheel

Three anode furnaces are proposed for the Copper Smelter Plant – II and twin caster wheel will be provided. The design detail of anode furnaces (3 Nos.) is given in Table-1.5.

TABLE-1.5
DETAILS OF ANODE FURNACE

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Details</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blister copper</td>
<td>310 tonnes</td>
</tr>
<tr>
<td>2</td>
<td>Casting machine</td>
<td>Twin Caster</td>
</tr>
<tr>
<td>3</td>
<td>Casting capacity</td>
<td>110 tonnes/hr</td>
</tr>
<tr>
<td>4</td>
<td>Anode weight</td>
<td>390 kg</td>
</tr>
<tr>
<td>5</td>
<td>Copper in anodes</td>
<td>99.5%</td>
</tr>
</tbody>
</table>

1.5.6 Off Gas Handling

1.5.6.1 Primary Gas Handling System

The ISASMELT furnace will be maintained under negative pressure at all times to prevent uncontrolled escape of hot process SO2 bearing off -gases. These gases will be utilized for the recovery of the sulphur content as saleable by product of Sulphuric acid.

The hot SO2 gases from the ISASMELT furnace, before being led to the Sulphuric acid plant will pass through a waste heat recovery boiler (WHRB) to recover the
heat to produce approximately 75 t/h of steam at 77 bar pressure. The WHRB will have a radiant section and a set of convection bank pendant tubes. The steam produced in the WHRB of ISASMELT will be utilized to produce 7 MW (average) of power in a condensing steam turbine set. The low-pressure steam produced will be utilized to drive the various feed pumps, and circulations pumps of the WHRB and other process applications.

A major content of the dust carried over in the off-gases will be recovered underneath the WHRB through an air cooled drag chain conveyor and fed to a crusher together with the ESP dust for grinding to a size fraction suitable for pneumatic conveying to the recycle bin located in the day bin building.

Off gases from the waste heat recovery boiler cooled to a temperature of 350ºC are further conveyed to a hot ESP to achieve a dust content of less than 100 mg/Nm³. To maintain the manometric balance for the downstream equipment described above and maintain a negative suction pressure at the ISASMEMLT furnace inlets an intermediate fan (ID fan) having a capacity of 120,000 Nm³/hr will be provided after the hot ESP. The ID fan will further deliver the off-gas to the gas cleaning section of the sulphuric acid plant for cooling and removal of the impurities before being sent to sulphuric acid plant for manufacture of Sulphuric acid.

1.5.6.2 Secondary Gas Handling System

Hygiene ventilation system has been envisaged for the following systems

**ISA / Rotary Holding Furnace**

i) A common double alkali scrubbing system shall be provided for the secondary gases generated in ISASMELT furnace, rotary holding furnace and Ferro sand cleaning furnace. This secondary scrubbing system can handle gas volume of 362,000 Nm³/h. Provision has also been kept for conveying the combustion off gases produced during the initial preheating of ISA furnace to the scrubbing system through a by-pass line.

**Converter / Anode Furnace**

ii) Secondary gases generated in PS converter and anode furnace shall be treated in a common double alkali scrubbing system. The secondary off-gas collected from secondary hood is conveyed by centrifugal fans having capacity of 470,000 Nm³/h to the scrubbing unit.

One common stack is envisaged for the entire ventilation & scrubbing system of ISASMELT, RHF, Ferro sand cleaning furnace, PS converters and anode furnace.

**1.6 Proposed Copper refinery, Rod plant and Precious Metal recovery Plant**

The refinery has been proposed to refine copper anodes to copper cathodes through electrolysis process and CCR has been proposed to treat copper cathode to produce copper rods by milling and rolling. In this project, a Precious metal and minor metal recovery plant is proposed.
1.6.1 Copper Refinery Process

The proposed Copper refinery capacity is 1525 TPD.

1.6.2 Copper Rod Process

The proposed rod plant capacity is 800 tpd.

1.7.1 Precious Metal Recovery Plant

Precious metal plant is a good value and pride plant for India. Hence new Precious Metal plant is proposed using state of the Art Technology. The Precious metal plant produces premium Gold, Silver, Platinum, Palladium will be recovered as Dore Metal for export, Selenium, Copper telluride, Bismuth Bi Sulphate, Nickel Sludge, and Nickel by refining slimes from the refinery and purification of Copper refinery electrolyte. The demand for precious metals as accessories and industrial materials is continuously growing due to its excellent chemical characteristics as well as superior workability in fabrication. Gold is widely used in the electronics industry, dental service, and as jewelry. Silver is used for soldering contacts, welding, plating and jewelry. Platinum and palladium are mainly used for catalysts in the automobile and petrochemical industries as well as jewelry and dental materials. Selenium is more wanted in Europe, China, US, and South American Region. It is mainly used in various industrial materials, such as a glass coloring agent, or in the sensitizer of a copying machine.

1.7.3.1 PMR from Electrolyte Purification Process

1. Copper Telluride Recovery

Process Description

During copper leaching of anode slime, tellurium dissolves in the electrolyte. Tellurium is removed by cementation process using copper shavings by heating the electrolyte upto 95 – 105 °C in a tank (in the baskets designed for this purpose) and the electrolyte is re-circulated. Copper reacts with Tellurium to form Copper telluride which is filtered in a filter press and dried for sale.

Schematic diagram for Copper Telluride recovery is shown in Figure- 2.7(A).
Input and output details for Copper Telluride recovery process are presented in Table-1.6.

**TABLE-1.6**

**INPUT AND OUTPUT DETAILS FOR COPPER TELLURIDE RECOVERY PROCESS**

<table>
<thead>
<tr>
<th>Input</th>
<th></th>
<th>Output</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrolyte-CuSO₄</td>
<td>30</td>
<td>Copper –Telluride (Cu-Te)</td>
<td>48-75</td>
</tr>
<tr>
<td>Copper Shavings</td>
<td>302</td>
<td>Electrolyte-CuSO₄</td>
<td>48</td>
</tr>
<tr>
<td>Water</td>
<td>2</td>
<td>Water Vapour</td>
<td>12</td>
</tr>
<tr>
<td>Steam</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Impacts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>Nil</td>
</tr>
<tr>
<td>Air</td>
<td>Water vapour</td>
</tr>
<tr>
<td>Water</td>
<td>3.6 m³ / day</td>
</tr>
<tr>
<td>Noise</td>
<td>Nil</td>
</tr>
</tbody>
</table>
2. **Bismuth Recovery Plant Based on MRT Technology**

*Technology Description*

MRT has been used since 1990 in Hydro metallurgical operations for Impurity control and metals refining. The technology has been reviewed extensively and has proven to be very effective as an impurity removal strategy. MRT uses solid phases resins that contain selective metal recognition sites. The metal recognition is highly selective to the impurity metal versus the refined metal, allowing removal from the pregnant solutions.

*Process description*

The whole process flow is described in the following process cycle

1. (Loading) Electrolyte feeding from Cell house to the MRT Column.
2. (Pre-Wash). Feed solution is water or 2 M Sulphuric Acid.
3. (Elution) Feed solution is 9 M sulphuric acid solution.
4. (Post wash) Feed solution is water or 2M sulphuric acid.

In the loading cycle the Bismuth is retained by the resin. While the elution cycle the Bismuth is dissolved in the 9 M sulphuric acid Solution and finally Bismuth Bisulphate is precipitated once the temperature of the eluent is brought down.

Schematic diagram of the Bismuth removal process is shown in Figure1.7(B)

![Process Flow Diagram of Bismuth Recovery Plant](image-url)
Input and output details for Bismuth Recovery process are presented in Table-1.7.

**TABLE-1.7**

**INPUT AND OUTPUT DETAILS FOR BISMUTH RECOVERY PROCESS**

<table>
<thead>
<tr>
<th>Input</th>
<th></th>
<th>MTPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphuric acid</td>
<td>252</td>
<td>MTPA</td>
</tr>
<tr>
<td>Water</td>
<td>7500 m³/annum</td>
<td></td>
</tr>
<tr>
<td>Electrolyte Solution from the Cell house</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(feed containing Bismuth)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output</th>
<th></th>
<th>MTPA on dry basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bismuth Bisulphate</td>
<td>125-150</td>
<td>(about 40% Bismuth content)</td>
</tr>
<tr>
<td>Wash water</td>
<td>Negligible</td>
<td>Taken to WWTP</td>
</tr>
<tr>
<td>Electrolyte Solution going back to Cell</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>house (Bismuth free)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Environmental Impacts**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>Nil</td>
</tr>
<tr>
<td>Air</td>
<td>Nil</td>
</tr>
<tr>
<td>Water</td>
<td>22 m³/day</td>
</tr>
<tr>
<td>Noise</td>
<td>Nil</td>
</tr>
</tbody>
</table>

3. **Nickel Sludge Plant**

**Process Description**

Composition of Bleed Stream:

1. Cu : <1%
2. Sulphuric acid : 30 gpl
3. Arsenic : 3500 PPM
4. Nickel : 10-20 gpl
5. Calcium : 500 PPM
7. Magnesium : 150 PPM
8. Bismuth : 5-10 PPM
9. Antimony : 15 PPM

**Neutralization:**

- The bleed volume is stored in the collection tank.
- From there it is transferred to Reaction tank where it is neutralized to 4.6-4.9 pH by adding 48% pure caustic lye with agitation of bleed stream.
- The agitation can be done by running the agitator and also recirculating the bleed stream in the tank.
- Caustic is added slowly by caustic addition pump from caustic tank.
- During caustic addition, ensure that temperature will not exceed 85°C.

- After 30-min of agitation and recirculation, ‘As’ will be analyzed to ensure the complete removal of arsenic.

**Reaction Chemistry and Stochiometric requirement of NaOH and Na2S**

Reaction Chemistry of Neutralization reaction is as follows,

Neutralization:

\[ \text{H}_2\text{SO}_4 + \text{NaOH} = >\text{H}_2\text{O} + \text{Na}_2\text{SO}_4 \]

Filtration:

Once, the ‘As’ comes to BDL in bleed stream, the filtration is started to separate the sludges from the bleed Stream.

Evaporation:

1. Psychrometric evaporator
2. Evaporator –01
3. Evaporator-02

**Psychrometric evaporator(PE):**

Final filtrate from filter press is sent to psychometric evaporator through the cartridge filter to make the filtrate sludge free. (Psychrometric operation- any operation between air and water(moisture))

**Operation of PE:**

Psychometric evaporator is just like cooling tower. Liquid is circulated from the tray to top and from there it is sprinkled by having sprinkler. At the same time, induced draft fan which is at top starts sucking the air from atmosphere through the gap which existing in between tray and fills of packed bed.

During the operation of PE, when air moves from bottom to top it carries away the liquid droplet along with it. (i.e. humdification of air). This results in the loss of water content and hence Concentration of filtrate stream will increase. Since it is working on the principle of psychometric operation it is called as psychometric evaporator.

**Evaporator-01**

Liquid from PE is stored in feed tank. From there it enters the shell and tube evaporator where it is evaporated by applying steam at shell side. The outlet temperature of E-01 is maintained at 70° C as the feed stream is getting splashed inside the vapor liquid separator (VLS-01) where the vacuum of 400mmHg is maintained. So it results in flash evaporation. The feed is being circulated in-between the vapor liquid separator and evaporator –01, till it gets concentrated to the required specific gravity.
Evaporator-02

The Evaporator-02 is also the shell tube evaporator, with vapor and uncondensed steam from E-01 as heating medium. Similar to E-01, the liquid is under recirculation in between E-02 and Oslo crystalliser. Main Purpose of this evaporator is to saturate the Oslo volume by continuous evaporation.

Oslo Crystalliser:

Oslo crystalliser is the crystalliser cum evaporator where the liquid is evaporated by flash evaporation and it is crystallized by obtaining a cooling gradient. The top
portion of the Oslo is being called as VLS-02. At VLS-02, Liquid is getting splashed from E-02 outlet and the liquid gets vaporized and resulting in rise of Concentration of Oslo volume. As soon as, it reaches saturation condition it starts forming crystals as and when cooling gradient is obtained.

**Centrifuge:**

The crystals formed at Oslo crystalliser need to be continuously drained out to separate the liquid and crystals. The centrifuge is the mechanical separation device where centrifugal force is applied to drain the liquid out from the solid through by having the basket and filter cloth arrangement to get crystals of nickel and sodium sulphate.

The flow diagram of Nickel sludge preparation is shown above in Figure-1.7(C).

4. **Nickel Recovery Plant**

Composition of feed solution:
1. Nickel : 20 gpl
2. Arsenic : 14 – 20 gpl
3. Antimony : <120 ppm
4. Bismuth : <400 PPM

**Process description - Recovery of high purity nickel**

*The process aim is to deplete nickel using the EMEW® electrowinning cell. The EMEW® cell is ideally suited to the selective removal of nickel for this application, and the aim is to recover a nominal 1500 kg of nickel per day as a high purity nickel cathode. The plant would operate a single circuit to deplete nickel from 20 g/l to 2 g/l. This can be achieved using either continuous or batch processing.*

<table>
<thead>
<tr>
<th>Proposed Operational Conditions</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel in feed</td>
<td>g/l</td>
<td>20</td>
</tr>
<tr>
<td>Current density (max)</td>
<td>a/m²</td>
<td>600</td>
</tr>
<tr>
<td>Current per cell (max)</td>
<td>amps</td>
<td>300</td>
</tr>
<tr>
<td>Number of cells</td>
<td></td>
<td>90</td>
</tr>
<tr>
<td>Total cathode area</td>
<td>M²</td>
<td>45</td>
</tr>
<tr>
<td>Electroly temp. (max)</td>
<td></td>
<td>60 °C</td>
</tr>
</tbody>
</table>


1.7.3.2 PMR from Refinery Slime Refining

The expected annual slime quantity to be treated in our precious metal recovery plant is 1734 MT.

Typical analysis of Anode slime is detailed below.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Element</th>
<th>Unit</th>
<th>Typical Assay</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ag</td>
<td>%</td>
<td>20.00</td>
</tr>
<tr>
<td>2</td>
<td>Au</td>
<td>%</td>
<td>3.50</td>
</tr>
<tr>
<td>3</td>
<td>Pd</td>
<td>%</td>
<td>0.02</td>
</tr>
<tr>
<td>4</td>
<td>Pt</td>
<td>%</td>
<td>0.001</td>
</tr>
<tr>
<td>5</td>
<td>Se</td>
<td>%</td>
<td>20.00</td>
</tr>
<tr>
<td>6</td>
<td>Cu</td>
<td>%</td>
<td>2.00</td>
</tr>
<tr>
<td>7</td>
<td>Te</td>
<td>%</td>
<td>1.80</td>
</tr>
<tr>
<td>8</td>
<td>Bi</td>
<td>%</td>
<td>2.5</td>
</tr>
<tr>
<td>9</td>
<td>S</td>
<td>%</td>
<td>9.50</td>
</tr>
<tr>
<td>10</td>
<td>O₂</td>
<td>%</td>
<td>16.00</td>
</tr>
<tr>
<td>11</td>
<td>SO₄²⁻</td>
<td>%</td>
<td>25.00</td>
</tr>
</tbody>
</table>

The slime is in black powder form, having a particle size of < 0.5 mm. The extraction of precious metal is in four stages.

1. De-selenisation,
2. Dore Smelting,
The Process description of each stage is shown in **Figure-1.7(E)**.

**FIGURE-1.7(E)**  
PROCESS FLOW DIAGRAM OF PRECIOUS METAL EXTRACTION

**1. Selenium Recovery Plant**

*Technology /Process Description*

The technology is derived from M/s. Outotec, Finland. The slime from the copper leaching decopperised slime is dropped from the filter press plates onto the roasting trays. These are transported by forklift into the roasting furnace. The selenium is roasted from slime in the electrically heated furnace with a batch size of 2000 kg. The roasting temperature is 450°C. Oxygen and sulfur dioxide gases are fed as reagents into the furnace. The reaction result, selenium dioxide gas (SeO₂), is sucked from the furnace through the ejector into process solution. In this solution selenium dioxide is reduced to elemental selenium by sulfur dioxide. The elemental selenium is collected into the Circulation Tanks. The selenium is filtered, washed and dried. The recovered selenium is commercial grade selenium, purity min. 99.5 %.

Main reactions in the furnace, (1, 2 and 3) and in the circulation system (4) can be described:

Se + O₂ → SeO₂  \hspace{1cm} (1)

Ag₂Se + O₂ → 2Ag + SeO₂  \hspace{1cm} (2)

Ag₂Se + 2O₂ + SO₂ → Ag₂SO₄ + SeO₂  \hspace{1cm} (3)

SeO₂ + 2SO₂ + 2H₂O → Se + 2H₂SO₄ \hspace{1cm} (4)

The selenium free slime on the roasting trays is discharged into the feeding bin of the Doré-smelting furnace.
The Process description of Selenium Recovery plant is shown in Figure-1.7(F).

**FIGURE -1.7(F)**

**PROCESS FLOW DIAGRAM OF SELENIUM RECOVERY PLANT**

<table>
<thead>
<tr>
<th><strong>Input</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>De-copperised slime:</td>
<td>1734</td>
<td>MT</td>
</tr>
<tr>
<td>Water:</td>
<td>9</td>
<td>m³/MT</td>
</tr>
<tr>
<td>SO2:</td>
<td>0.8</td>
<td>MT/MT</td>
</tr>
<tr>
<td>O2:</td>
<td>0.4</td>
<td>MT/MT</td>
</tr>
<tr>
<td>Air:</td>
<td>125</td>
<td>m³/MT</td>
</tr>
<tr>
<td>Steam:</td>
<td>0.7</td>
<td>MT/MT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Output</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>De-selenised slime:</td>
<td>1296</td>
<td>MT</td>
</tr>
<tr>
<td>Selenium:</td>
<td>438</td>
<td>MT</td>
</tr>
<tr>
<td>Gas:</td>
<td>150</td>
<td>KNm³/MT</td>
</tr>
<tr>
<td>WWTP bleed:</td>
<td>7.0</td>
<td>m³/MT</td>
</tr>
</tbody>
</table>

**Environmental Impacts:**

<table>
<thead>
<tr>
<th>1</th>
<th>Land:</th>
<th>Nil</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Air:</td>
<td>Emission of gas 500 Nm³/ Hr containing SO2 : 100 mg/Nm³, Co2 : 0.1%,Nox:&lt;1 gm/batch, H₂O content : 25% max and solid : 300 mg/Nm³, Temperature : 80 C, Velocity : 3 m/s</td>
</tr>
<tr>
<td>3</td>
<td>Water</td>
<td>Consumption of 9 m³ / MT of De-Copperised slime</td>
</tr>
<tr>
<td>4</td>
<td>Noise:</td>
<td>Nil</td>
</tr>
</tbody>
</table>
2. **Doré Smelting Process**

The Process description of DORE smelting is shown in **Figure-1.7(G).**

**I step: Doré Anode preparation from Slime**

De-selenised slime is mixed with the fluxes like Soda, borax (anhydrous), cement and smelted in Doré furnace (TROF-converter) at 1300 deg c. After refining the metal, it is casted as anodes by tilting the converter. The slag is also separated out in this process. Primary slag is recycled in copper smelter and the secondary slag is re-smelted in Doré furnace back.

**FIGURE -1.7(G)
PROCESS FLOW DIAGRAM OF DORE SMELTING PLANT**

1.8 **Proposed Project – Acid Plants**

1.8.1 **Sulphuric Acid Plant Process (SAP)**

For the Copper Smelter plant -II, sulphuric acid plant having capacity of 5900 TPD will be provided to handle the gas volume of 3,90,000 Nm³/h. A Gas cleaning plant is proposed for this SAP.

1.8.2 **Phosphoric Acid Plant (PAP)**

For the Copper Smelter plant -II, Phosphoric acid plant having capacity of 800 TPD will be provided.

1.9 **Proposed Project – Utilities and WWTP**

1.9.1 **Utilities**

It is proposed to install RO plant of capacity for the treated wastewater. As part of this project, it is proposed to install one (1) new oxygen plant.

It is proposed to install one Desalination Plant of 10000 m³/day capacity in the coastal area to meet the additional raw water requirement.
1.9.2 Wastewater Treatment Plant (WWTP)

WWTP-1, 2 and WWTP 3 will be provided for waste water generated from the proposed project facilities.

1.10 Project Cost

The total cost for the proposed Copper Smelter Plant -II project is estimated as Rs.2500 Crores. The break-up of project cost is presented in Table-1.8. The environmental protection cost including the chimney in the total project cost is about Rs. 475 Crores.

**TABLE-1.8
DETAILS OF PROJECT COST**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Cost in Crores Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basic process equipments and machineries</td>
<td>1500</td>
</tr>
<tr>
<td>2</td>
<td>Civil structures</td>
<td>275</td>
</tr>
<tr>
<td>3</td>
<td>Utilities</td>
<td>140</td>
</tr>
<tr>
<td>4</td>
<td>Air Pollution Control Measures (SAP, ESP)</td>
<td>475</td>
</tr>
<tr>
<td>5</td>
<td>Wastewater Pollution Control Measures (WWTP, STP)</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>Environmental Improvement Plans (Double hood and Energy conservation)</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>2500</strong></td>
</tr>
</tbody>
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