Pre-feasibility Study
For
Caustic Soda/ Chlorine Plant
Base Capacity: 25 Ton per day of Caustic Soda
Capacity Expansion for 50 TPD After 4 Years of Operation

Paranthan Chemicals Company Ltd

18th March 2020
Executive Summery

Project proposes to manufacture following products

Caustic soda (100%) : 8,250 Ton per annum (25 Ton per day base capacity)
Chlorine (99.7%) : 3,500 Ton per annum (11 Ton per day)
Hydrochloric acid (32%) : 8,500 Ton per annum (25 Ton per day)
Sodium Hypochlorite (12%) : To be decided depending on the market size

Estimated Capital : Rs 2,800 Million

Total Number of Direct Employment : 40
Annual Salt Requirement : 12,400 MT
Electricity Demand : 3.5 MW
Project Location : Paranthan, Kilinochchi District, Sri Lanka
1. Introduction

Caustic soda is a base chemical needed in many industries in Sri Lanka. It is used as a raw material as well as for various other uses in industrial applications such as textile dyeing industry, food industry, electroplating industry etc. As a raw material it is mainly used in soap industry in Sri Lanka. Caustic soda is used in the form of solution (Lye) of different concentrations vary from industry to industry ranging from 32% to 50%. For soap industry it is mainly 45% concentration, while for industrial cleaning applications lower concentrations are used depending on the industry.

Caustic soda is imported to Sri Lanka in solid forms either as flakes or frills, packed in bags. A small quantity is imported in liquid form (Lye) by textile mills. All the users of caustic soda in the industry use caustic soda in liquid form by dissolving flakes or frills to make lye or liquid, which again is a cumbersome process. Due to the difficulty of importing in liquid form, bulk of caustic soda is imported to the country in solid forms. In the proposed caustic soda plant, it is proposed to produce caustic soda in the liquid form (Lye). This will not only be cost effective to produce, but also less capital intensive process. As such caustic soda is proposed to be produced as a liquid of 50% concentration in the proposed project. Caustic liquid of 50% concentration shall be transported in tankers to the bulk consumers such as soap manufacturers and textile industries. This will also reduce the packaging cost, handling cost and transportation cost, thereby making the supply chain more ecofriendly compared to present practice of imported in 25 kg bags.

Chlorine gas is produced as a byproduct in the production of caustic soda, in the ratio of 1: 0.89, that is production of one ton of caustic soda will produce 0.89 ton of chlorine. Chlorine will be produced in excess as a byproduct in the process of manufacture of caustic soda. Considering 25 ton per day (TPD) base capacity of caustic soda production, plant will produce 22.25 Ton per day of chlorine gas. Which is a very high volume than the demand for chlorine in the country. National demand for chlorine is 3200 ton per annum for water purification and other industrial applications. Apart from direct sale of chlorine for water purification and other industrial sectors, chlorine will be utilized within the plant to produce hydrochloric acid (HCl) which is one of the four main products proposed in the project.

Proposed plant capacity of 25 ton per day (TPD) of caustic soda can produce 8,250 MT of caustic soda per year, considering 330 days of plant availability for production. However in order to manage excess chlorine production, it is planned to limit caustic soda production to around 6,900 to 7,000 MT per year at the beginning (83-84% capacity utilization) and to increase capacity utilization gradually with projected increase of chlorine consumption.

At the moment hydrochloric acid is imported in polypropylene cans of 30 kg capacity. Due to the very high packaging cost, current market price of hydrochloric acid is not attractive to use HCl as a feed stock for other industries. However once HCl is locally produced, HCl can be transported in tankers for bulk consumers who use HCl as a feed stock for other industries. Transportation of HCl in tankers will bring down the price of HCl by approximately 50% by eliminating packaging cost. This will not only open opportunity to new industries, but also will
be ecofriendly by eliminating packaging. HCl shall be sold in 30kg cans for the users who use in small quantities for many other applications such as electroplating industries, PH adjustment in wastewater treatment plants etc. etc.

Paranthan Chemicals Company Limited (PCCL) plan to promote several downstream industries for SME sector to use hydrochloric acid as a feed stock. This will not only make the caustic soda project more viable, but it will give opportunities for SME sector to start new industries. Some of the downstream industries PCCL is planning to promote are poly aluminium chloride, calcium chloride, ferric chloride and gelatin production. All these industries use HCl as a feed stock. Considering demand for HCl as a feed stock for the downstream industries and demand for HCl for other miscellaneous uses, HCl production in the caustic soda project is proposed to be 8500 Tons per annum, whereby 2650 tons of chlorine will be consumed for HCl production.

Considering current total demand for chlorine, a caustic soda plant of base capacity 25 ton per day is proposed to be set up with adequate infra-structure for 50 Ton per day so that capacity can be increased to 50 ton per day after few years of operation. Demand for chlorine and hydrochloric acid can increase gradually once these chemicals are available locally as a feed stock for other industries. When the demand for chlorine and hydrochloric acid increases, base capacity of the caustic soda plant can be enhanced.

It is proposed to leave out downstream products of the project such as poly aluminium chloride, calcium chloride and ferric chloride from the main project. Objective is to give opportunities for the SME sector, especially to the investors of the Northern Province, to set up industries related to chemical industries. There are several other downstream industries such as bleaching powder, chlorinated paraffin for which chlorine will be required. Once the caustic soda project takeoff, opportunities will be open for many other downstream industries using caustic soda, chlorine and hydrochloric acid as feed stock. Caustic soda project will open up opportunities for investors to transform Paranthan Land to a major chemical industrial park.

Project location will be at Paranthan, in Kilinochchi district. Paranthan Chemicals Company Limited, which is a government company operating under purview of the Ministry of Industry and Supply Chain Management, demarcated 20 acres extent in the land belongs to Paranthan Chemicals Company Ltd for the caustic soda project. A cluster of downstream industries is expected to develop around caustic soda project.

It is planned to develop the entire land of 160 acres available for development to a major chemical industrial park with many other chemical industries. Caustic soda project will make a head start and investment in this project will have advantage of entering into other chemical industries planned for this park.

Proposed capacities of the caustic soda plant,

Base Capacity- 25 TPD of Caustic Soda (100% basis) and expansion into 50 TPD after 4 years of operation

This plant shall produce following final product mix with following annual quantities.
1. Caustic Soda: 13,800 MT (Plant will produce 50% liquid)
2. Chlorine: 3,500 MT (99.7%)
3. Hydrochloric Acid: 8,500 MT (32%)
4. Sodium Hypochlorite: (12%) quantity to be decided upon market size

This plant will meet entire national demand for chlorine, Hydrochloric acid & sodium hypochlorite. Capital Investment estimate is around Rs.2800 million (Capital Estimate can be 10-15% vary depending final contract value).

2. Background of the Project

Paranthan Chemicals Company Limited (PCCL), started as Government Chemicals Factory in late 1950’s later incorporated as Paranthan Chemicals Corporation was having a caustic soda plant at Paranthan producing caustic soda, chlorine, hydrochloric acid, sodium hypochlorite and ferric chloride. Plant has to shut down in 1985 due to the civil war situation in the North and plant was destroyed during war. Paranthan Chemicals Company Limited thereafter imported and supplied these chemicals, especially chlorine, to meet the national demand. As chlorine is a essential chemical for water purification, PCCL continued to supply chlorine uninterruptedly to Water Board. PCCL also supply chlorine to several other industrial users. In addition to chlorine PCCL is also import and supply caustic soda and hydrochloric acid.

Chlorine is distributed to customers in cylinders. Chlorine gas is compressed and liquified so that large volume of chlorine can be transported in each cylinder. Chlorine is sold to customers in cylinders of capacity 68 kilo gram and 900 kilo gram. PCCL has a large stock of cylinders of each capacity to meet the demand of Water Board locations throughout the country and other industrial users. PCCL is currently engaged in the liquefied chlorine distribution business and PCCL will retain the exclusive distributorship of liquefied chlorine in the local market.

3. Project Implementation Plan

Business Model

Paranthan Chemicals Company Limited will implement the caustic soda project directly (Project Implementation Agency will be Paranthan Chemicals Company Ltd). Caustic soda project will be functioned as a strategic business unit. Forming a new company under the companies act to operate the caustic soda project is an option.

Considering the complexity of the project, plant shall be designed, supplied, erected and commissioned by an international contractor. An EPC contractor (Engineering, Procurement and Construction contractor) will be selected through procurement procedure (International Competitive Bidding) for design & supply of equipment, erection and commissioning of the plant. While civil contractor/contractors shall be selected by calling national bids for the civil construction works as per the detail Engineering drawings provided by the EPC contractor.
Estimated Capital Costs of the Project

<table>
<thead>
<tr>
<th>Investment Activity</th>
<th>Investment in LKR</th>
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</thead>
<tbody>
<tr>
<td>Buildings/Civil Works</td>
<td>200,000,000</td>
</tr>
<tr>
<td>Plant &amp; Equipment</td>
<td>2,400,000,000</td>
</tr>
<tr>
<td>Vehicles</td>
<td>90,000,000</td>
</tr>
<tr>
<td>Working Capital</td>
<td>110,000,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,800,000,000</strong></td>
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</tbody>
</table>

Note: Capital Cost can vary by 10-15%

4. Objectives of the Project

1. Production of chlorine required for water purification and thereby ensuring water security of the country.
2. To produce caustic soda/chlorine/Hydrochloric Acid which are some of the base chemicals required for the sustainability of existing industries of Sri Lanka.
3. To promote private sector participation in the chemical industry of Sri Lanka by giving opportunity to the SME Sector for downstream chemical industry of caustic soda project.
4. Productive use of Paranthan Chemicals Company land for industrial development of the Northern Province.

5. Benefits to the Community of the Northern Province and the Country as a Whole

1. Increased investment in the Northern Province
2. Development of SME sector chemical industries- development of downstream chemical industries thereby development of a sustainable chemical industry of the country
3. Direct and Indirect employment generation
4. Development of Human Resource in the field of Chemical Industry
6. Proposed Product Mix

<table>
<thead>
<tr>
<th>Product</th>
<th>Annual Production (MT)</th>
<th>Daily Production (MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caustic Soda (50% liquid)</td>
<td>13,800</td>
<td>50</td>
</tr>
<tr>
<td>Chlorine (99.7%)</td>
<td>3,500</td>
<td>11</td>
</tr>
<tr>
<td>Hydrochloric Acid(32%)</td>
<td>8,500</td>
<td>25</td>
</tr>
<tr>
<td>Sodium Hypochlorite(12%)</td>
<td>TBD depending on mkt size</td>
<td></td>
</tr>
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</table>

TBD: To be decided

Introduction to the main products of the Project

1. **Caustic soda**: Caustic soda is a base chemical for many other secondary industries. In Sri Lankan context, Soap industry is the main consumer of caustic soda. In addition caustic soda is used in textile dying industry as another main user of caustic soda. Once caustic soda is available locally there can be several other downstream industries can evolve. Caustic soda is imported to Sri Lanka at the moment mainly in flakes forms such as flakes and Frills packed either into 25 kg bags or 50 kg bags. In addition caustic soda in liquid form of 50% concentration is imported in smaller quantities packed in 1500 kg tanks. Caustic soda is used in the industry in liquid form of varying concentrations from 32% to 50%. As import in liquid form is expensive due to excessive packaging cost, bulk of caustic soda is imported to the country in flakes forms packed in bags. End user has to convert the flakes into liquid form by dissolving in water, whether it is used in soap industry, textile industry or any other industry. This dissolving process is a tedious process due to safety and environment reasons. Local production will be in liquid form and it will get rid of packaging cost as well. Caustic soda produced in liquid form can be transported in tankers or bowsers to the customer locations. As most of caustic soda users are bulk users, transportation can be done in bowsers. For small scale users, caustic soda can be filled into 200 kg drums and 30 kg cans and transported to customer locations. For regular customers who use in smaller quantities, drums or cans shall be on returnable basis so that packaging cost can be eliminated and also it will be environmentally friendly as packaging will be re-used.

2. **Chlorine**: Chlorine gas produced in the production of caustic soda by electrolysis of salt solution. Chlorine gas is produced at the rate of when 1 ton of caustic soda is produced 0.89 ton of chlorine is produced. Chlorine gas is used for production numerous other secondary products varying from production of PVC raw material (vinyl chloride monomer) to agrochemicals. Vinyl chloride monomer production process is a highly capital intensive project, where smallest size vinyl chloride plant will be in the range of US$ 650 million.
Chlorine gas although used for disinfecting drinking water, chlorine gas can be dangerous gas if inhaled. Inhalation of chlorine causes choking of the throat and can even lead to death. Therefore any excess chlorine produced in the production of caustic soda has to be either converted to a downstream product or destroyed. In order to destroy chlorine, it has to be converted to hydrochloric acid first and react with limestone powder. Therefore destroying incurs cost as it requires lime stone. Destroying of chlorine may not be an option in normal circumstances. However it could be an option if the caustic soda market price is impressive. In some of the plants in the region, chlorine is converted to hydrochloric acid and give out free of cost to other industrialist or destroy using lime stone, whenever they have impressive demand and price for caustic soda.

In Sri Lankan context, demand for hydrochloric acid can grow once caustic soda project is launched. When hydrochloric acid is available at a cheap price or free of cost, number of other industries using hydrochloric acid as a raw material would evolve and create opportunities for many other projects for SME sector. Poly aluminium chloride, bleaching powder, ferric chloride, zinc chloride and calcium chloride are some of the secondary chemicals that can create opportunities for SME sector in Sri Lankan context.

3. Hydrochloric acid: Hydrochloric acid (HCl) is produced using two of the byproducts produced during production of caustic soda. Those are chlorine and hydrogen gas. Hydrochloric acid is used to produce several other secondary chemicals (or Downstream products) such as poly aluminium chloride, ferric chloride, calcium Hypochlorite and calcium chloride.
   All Excess chlorine available will be converted to HCl to produce above said secondary chemicals and other downstream products. One such industry is extraction of gelatin from cows bones. It is a lucrative industry in Bangladesh.

Hydrochloric acid can be transported in tankers or bowsers to the customer locations for bulk users. For small scale users, HCl can be filled into 200 kg drums and 30 kg cans and transported to customer locations. For regular customers who use in smaller quantities, drums or cans shall be on returnable basis so that packaging cost can be eliminated and also it will be environmentally friendly as packaging will be re-used.

4. Sodium Hypochlorite (Hypo): This is a byproduct produced in caustic soda plants, which is produced using chlorine, which has a market value. Sodium Hypochlorite (Hypo) is produced in concentration of 12 % or 15%. This product is used as a disinfectant and as a bleaching agent. This product can be sold in 30 kg drums and drums returnable basis for regular customers to eliminate packaging cost.
   Hypo is used as a disinfectant in hospitals, public places, household use etc. and as a bleaching agent for whitening hospital bed linen, school uniforms and other white clothes.

This product too will generate opportunities for small scale industries for repacking into retails cans of smaller size packs and for sale in supermarkets etc.
7. Market

Caustic soda is imported to Sri Lanka in flakes form which has a concentration of 98%. However all the users of caustic soda convert flakes into liquid form by dissolving in water. Different users use different concentrations from 30% to 45% depending on their usage. Proposed plant will produce caustic soda of liquid form with a concentration of 50%.

Current chlorine demand is 3200 MT per year. It is estimated that the chlorine demand increase at the rate of 3% annually due to new projects of water board & expected a demand of 3500 MT per year by the year 2022, when the project commences production.

Selling & Distribution Channels

All the chemicals are industrial chemicals and sold in bulk to industrial consumers. Selling and marketing will be carried out by the marketing section of PCCL. As the PCCL is currently engaged in selling of all the four chemicals proposed in the project, markets of the four chemicals are familiar with PCCL marketing staff.

Chlorine: Chlorine will be sold in 900 kg capacity cylinders and 68 kg capacity cylinders. 80 % of chlorine sale is for the Water Board sites throughout the country. PCCL shall outsource the chlorine distribution to a transporter by calling a transport tender yearly basis.

Caustic Soda: Caustic soda is mainly used by soap manufacturers and textile industries. In addition pettah traders are dealing with caustic soda sales. Caustic soda will be sold mainly for few direct customers. Caustic soda will be produced in liquid form in 50% concentration. Caustic soda will be transported to customer locations by tankers each with 25 Ton capacity. Two tank loads per day will leave production plant. Caustic soda distribution shall be outsourced to a transporter. PCCL shall outsource the caustic soda distribution to a transporter by calling a transport tender yearly basis.

Hydrochloric acid (HCl): HCl will be sold in 30 kg cans (retail packaging) to chemical dealers as well as HCl will be sold in bulk to the proposed downstream industries to manufacture of poly aluminium chloride etc.

HCl in retail packaging will be transported to customer locations by lorries each carrying about 15 Ton capacity. HCl distribution shall be outsourced to a transporter. PCCL shall outsource the HCl in retail cans distribution to a transporter by calling a transport tender yearly basis.

Bulk sales is planned to be sold to downstream industries of poly aluminium chloride (PAC) & other downstream industries. This will be transported (pumped) by pipeline to the proposed industries, which are planned to be set up around the caustic soda plant.

Sodium Hypochlorite (Hypo): Hypo will be sold in 30 kg cans (retail packaging) to chemical dealers as well as direct sales to corporate customers.
Hypo in retail packaging will be transported to customer locations by lorries each carrying about 15 Ton capacity. Hypo distribution shall be outsourced to a transporter.

PCCL shall outsource the Hypo & HCl in retail cans distribution to one transporter by calling a transport tender yearly basis.

8. Development of SME Chemical Industrial Sector

With the objective of development of SME sector in the Northern Province, it is proposed that the above downstream industries to be developed by the SME sector to start production facilities within the Paranthan Chemical Industrial Park.

Apart from the products listed above, there will be many other downstream industries utilizing caustic soda, chlorine and hydrochloric acid as feed stock, which would create a cluster of industries around the caustic soda project within the Paranthan Chemical Industrial Park.

9. Raw Material Supply

Main raw material supply will be salt with an annual requirement or 12,400 Tons for the proposed production capacity during Phase 1 of the project. As the plant is planning to be set up in Paranthan, salt can be transported in tractors from Elephant Pass Salterns. Daily requirement will be around 38 tons. Salt shall be supplied from Elephant Pass saltern, which is about 5 km from the proposed Paranthan site.

It is required to sign a Salt Purchase Agreements with Manthai Salt Ltd, who operate the Elephant Pass Saltern and Kurunchathiv Saltern, under the Ministry of Industry and Commerce, to ensure uninterrupted supply of salt at an agreed price for an agreed period of time. Salt Purchase Agreement shall keep provision for revision of salt price every five years or as per the period of time agreed in the agreement.

10. Infra-Structure

Land of Paranthan will have all key infra-structure within its boundary limits. Land provided by PCCL will have road frontage to the Northern main highway, A9 Road. And Northern railway track passes through the front side of the land with Paranthan rail station within 300 meters from the land. 33 kV electricity supply line is in the front of the land. Ground water of reasonably good quality is available in the two tube wells functioning in the Project site. A water quality test was carried out in the year 2013 in a water sample drawn from a tube well in the site. Water quality is found to be suitable for the process water of caustic soda plant after suitable treatment.
i. **Land:** A land area of extent 160 acres is demarcated for the proposed Chemical Industrial Park. It’s a flat land located at Paranthan in, Killinochchi District. Land is facing Colombo-Jaffna highway (A9 Road), and 330 Km North of Colombo.

ii. **Electricity Supply:** This land is located facing A9 Road with 33kV electricity supply line available in the front side of the land.

iii. **Water Supply:** Water supply from National Water Supply and Drainage Board (NWSDB) is available at Paranthan area with a present supply capacity of 3500 cubic meters per day and they have planned to add another 4500 cubic meter capacity in the near future. NWSDB water source is Iranamadu Reservoir which is located 12Km from the Paranthan junction. Limited water supply will be available to the Paranthan Chemical Industrial Industrial Park from the NWSDB.

   Ground water is another alternative water source. There are two bore holes within the site with a good yield (Yield is not estimated). It is planned to drill 2 to 3 bore holes to establish water supply to the project. However ground water shall be an interim plan to meet the water demand for the project.

   **Sea Water Desalination Plant:** As a sustainable alternative to water supply from NWSDB, it is proposed to set up a sea water desalination plant (SWD Plant) so that a sustainable supply of water is available for the Paranthan Chemical Industrial Park.

   There is no sea near Paranthan land and Jaffna Lagoon is 3.5 Km away from the Paranthan land. Therefore, it is proposed to set up SWD Plant in Elephant Pass Saltern (EPS) premises, which is 6 Km away from Paranthan land. Wastewater is produced in the desalination plant with a high salinity. There is a possibility that this wastewater (Brine) can be fed into the salt concentration pans of the EPS after suitable treatment and thereby increasing the salt production at the EPS. Water produced in the SWD Plant with sufficient capacity at EPS premises shall be pumped to Paranthan Site by a 6 Km long and 3 inch diameter pipe line.

iv. **Road Transportation:** Paranthan Land is located facing A9 Road. Therefore road transportation of raw materials and finished products is conveniently possible.

v. **Rail Transportation:** Northern railway track passes through this land towards the eastern boundary of the land (parallel to the A9 Road) and the Paranthan Railway station is close to the Southern end of the land. It is proposed to lay a rail track to the land and have a loading and unloading station with container handling equipment. Accordingly, it will facilitate the industrialists to make their import and export convenient. Containerized cargo can be imported and exported directly from and to the port through rail transportation.
11. Environmental Feasibility

Paranthan land, where caustic soda project is planning to be set up was the site where a caustic soda plant was in operation years ago. Entire land has an area of 160 acres demarcated for chemical industrial complex. 20 acres is demarcated in the middle of the land (as shown in the site plan annexed) for the caustic soda project. Downstream industries shall be set up around the caustic soda plant so that caustic soda, hydrochloric acid or chlorine shall be available through pipeline to the downstream industries. A green buffer zone is under development since 2014 in the 20acre area demarcated for caustic soda project with 1200 trees planted. Green buffer zone is a requirement of Central Environmental Authority (CEA). 200 meters of separation zone can be maintained from the residential areas of all sides to the process area, which gives advantage in obtaining Environment Protection License from CEA.

Proposed plant has the salient features of zero gas emissions by having in built chlorine-waste Air De-chlorination unit or Sodium Hypochlorite Plant (Hypo Plant). During start up and shut down chlorine from Cell House is diverted to Hypo Plant. Also in case of any leakage or excess pressure in the process, chlorine will get sucked by the Hypo Plant. Sodium Hypo Chlorite is a very valuable product and can be sold in the market easily. Waste Chlorine header will be laid in the total plant wherever there is a chance of any chlorine leakage also all the vents and seal pots provided in the chlorine line will be connected to Suction Header.

This plant is capable of taking full load for 10 -15 minutes of operation.

Liquid waste generated in the brine purification process will be treated and returned back to salt dissolving process so that there will not be any liquid waste generated within the plant.

A solid waste generated will contain no hazardous material, which will contain calcium carbonate, magnesium hydroxide and barium sulphate. This can be made use of to produce cement blocks for building construction or as a land fill.
12. Production Process

Production process consists of 6 main processes,

1. Brine purification plant
2. Electrolyzer
3. Chlorine Drying and Liquefaction Plant
4. Hydrochloric production process
5. Hypo production process

Production process starts with main raw material salt. Salt is dissolved in water to prepare brine & as raw salt contains impurities these impurities need to be removed in an intense purification process in a several stages.

After purification process, brine is fed to the Electrolizer, where brine is electrolized to produce Sodium Hydroxide. Chlorine gas & Hydrogen gas are produced as byproducts in the anode and cathode of the electrolizer. Brine is electrolized using low voltage with a ultra high current flow. And electrical energy is converted to chemical energy in this process to break salt to produce Sodium Hydroxide, Chlorine & Hydrogen. Chlorine gas and Hydrogen gas is used to produce Hydrochloric acid. Surplus chlorine gas is compressed, liquefied and stored in 25 ton capacity tanks for filling into tonners.

Caustic soda is produced at a concentration of 31-32 % caustic lye in the electrolizer. Caustic Lye is then transferred to Caustic Concentration & Flaking Plant. At this plant caustic lye of 32% is concentrated in two stages. Caustic lye of 45 % is taken after first stage of concentration & sold as caustic lye. This is transported in bowsers for soap manufacturers etc.

Brine purification plant can be classified into following four sections,

Primary Brine Purification Unit
Secondary Brine Purification Unit
Depleted Brine Treatment Unit
Brine Sludge Treatment Unit
Simplified Equipment Diagram of Primary Brine Purification section

Simplified Equipment Diagram of Secondary Brine Purification section
Simplified Equipment Diagram of Depleted Brine Treatment and Chlorate Decomposer

Simplified Equipment Diagram of Brine Sludge Treatment Section
Chlorine Liquefaction Unit
Hydrochloric Acid Plant

SODIUM HYPOCHLORITE PLANT

Cl₂ gas comes out from Cell House, Cl₂ filling unit and HCl synthesis unit.

Waste Cl₂ is absorbed by diluted caustic soda solution at low temperature (below 15.5°C)
13. PROCESS DESCRIPTION:

13.1 Brine Purification Process:
Brine for Membrane Chlor-alkali process is prepared by dissolving crystal salt into the Return brine from the electrolyser, and is purified with chemicals in order to precipitate the impurities of raw salt. Process however, requires a very high purified brine, and this is performed by pre coated filter and ion exchange resins.

16.2.1 Primary Brine Purification
The return brine is fed from top to the bottom of Salt Saturator and is saturated with Salt while the brine flows upwards through the salt bed in the saturator. Crystal salt is continuously supplied to the top of the saturator by salt conveyor. Temperature of the return brine is controlled by Return Brine heater so as to maintain the saturated brine temperature within 60-65 Deg. C. The saturated raw brine overflows from the saturator into the Reactor by gravity flow. Chemicals, such as caustic soda, barium carbonate and sodium carbonate, are added to the saturated raw brine flow. Dissolved impurities of raw brine (Ca, Mg and SO₄) react with these chemicals and precipitated as CaCO₃, Mg(OH)₂, and BaSO₄ from the solution in the reactor. This suspending solution is sent to the center well of Brine Clarifier and is separated to sediment and solution.

A part of sludge (Sediments collected at the bottom of Clarifier) is recycled back to the Reactor in order to form big size particles of sediments. Flocculent is also added to the stream of suspending solution to make bulky sediment and Clarified brine overflows from Brine Clarifier to Clarified Brine Tank. Slurry from Clarifier Slurry Pit and Filter Slurry Pit is sent to Sludge Filter to recover the brine in the slurry. Recovered brine is fed to Return brine Tank. The clarified Brine from clarified Brine tank is then filtered through primary Brine filters packed with Anthracite as filter media to filter the Brine.

IM Electrolyser need a very high quality, Impurity free Brine for trouble free Electrolyser operation. Hardness should be reduced to minimum and Trace Metals shall be almost removed.

Purified Brine from primary Brine Section is further purified by Secondary Brine Candle filtration and Ion Exchange resin adsorption system

13.2 Secondary Brine Purification System
It consists of two sections.

- Brine Filters
- Ion-Exchange Resin System
Candle filtration:
In a membrane based caustic chlorine plant, the content of suspended solid in the filtered brine must be kept very-very low because suspended solids above certain level will plug the Ion Exchange Resin and contains heavy metals which are very harmful for Electrolysis.

A special care is required while designing a Brine Filtration System for smooth operation of Electrolyzer. Suitable carbon candles filtration system shall be in place.

The operating process of a candle filter can be divided into following four steps:

Step No.1 — Preparation of Precoat
Filtrate brine of the required quantity is filled into the filter. This process is performed immediately after the completion of washing process except the initial start. a — cellulose of the required quantity is dosed into precoat tank. When "Precoat Tank Dosage Completion" button has been pushed and the required time has passed, filtered brine is filled into precoat tank and the agitation starts.

Step No.2 — Filtration
When saturated Brine passes through precoat layers formed on surface of filter elements from upstream to downstream, the fine impurities are trapped and removed. Body feed is automatically performed during recirculation and filtration process.

Step No.3 — Washing:
The impurities attached and alpha-cellulose on the surface of filter elements are removed and washed by flushing the clean Brine through filter elements from inside to outside. By washing filter elements are restored back to original state before reuse. Immediately after completion of washing process (except initial start up) filtered brine of required quantity is filled into the brine filter. alpha-cellulose of required quantity is dosed into pre-coat tank. After dosing of alpha-cellulose filtered brine is filled into pre-coat tank and Agitation is started.
Step No.4 — Precoat:

Filtered Brine mixed with alpha-Cellulose is sent into filter. alpha-Cellulose powder is attached evenly on the surface of filter elements and the pre-coat layers with L-cellulose are formed.

The layers contribute to achieve a fine filtration quality by preventing filter elements from blinding, which gives higher washing efficiency of filter elements.

13.3 Ion Exchange System:

Calcium and magnesium ion or other multivalent cations in the brine are very harmful to the membrane electrolysis process; generally these multivalent cations can be removed to some extent, by chemical treatment and sedimentation in primary purification. However, for stable operation of membrane process/brine purification by ion-exchange resin is required as secondary purification.

3-Tower Absorber merry-go-round type Ion-exchange system is preferred to avoid any risk to the Electrolyzer. 3 columns filled with Ion Exchange Resins shall be installed.

Two columns are normally on line in series and 3rd is lined for regeneration. After 16 hours the Primary Column is off lined for resin Regeneration and second column is elevated into a primary column and regenerated column is on-lined into a secondary column. The resin in off-lined column, in which large amount of multivalent cations have been absorbed is regenerated by hydrochloric acid and caustic soda. As per cycle each column is regenerated after every 32 hours. As all the columns are connected through automatically operated valves, switching takes place automatically through Programmable Logic Controller equipped with online analyzer for brine hardness.

Flow indication and control valves shall be installed in all the liquid lines connected to Ion-exchange system for automatically controlling the desired flow rates.

This specially developed ion exchange resin can remove multivalent cations (<20 parts per billion) harmful to the ion exchange membrane to such an extent as cannot be achieved by conventional chemical treatment.
13.4 ELECTROLYSIS PROCESS

Electrolysis section is composed of electrolyzer and associated equipment.

16.4.1 Electrolyser

Electrolyser is composed of a number of bi-polar type cell frames with metal anode and the activated cathode, the ion-exchange membrane, press units for mounting cell frames, sub-headers for feeding purified brine and Catholyte, sub-headers for discharging electrolysis products, hoses for connecting cell frames with sub-headers.

Super purified from chelate resin adsorption unit is fed through to each electrolyser manifold and then distributed to each anode chamber where it decomposes into chlorine and sodium ions. The super-purified brine flow rate to each electrolyser circuit is monitored by a flow controller equipped with individual feed brine branch pipe.

A two-phase stream of depleted brine and wet chlorine gas overflows from each anode chamber and is separated at the collection manifold equipped with electrolyser.

The depleted brine flows by gravity through the branch pipe, and common header into the depleted brine tank, while the chlorine gas is sent to Chlorine Gas Processing Section. From the tank, the depleted brine is pumped to deplete brine dechlorination system by level controller.

Two hydrochloric acid additions are considered for the recycle brine system to keep low oxygen concentration in chlorine gas. One is at the inlet of the depleted brine tank. This addition is provided to control acid concentration of the total system for dechlorination. Another is at the cell feed brine line.

Two types of chlorine gas pots are installed to protect the electrolyzers from excessive pressure surging in upset conditions: one for positive pressure relief and another for negative. Chlorine gas header pressure in the cell room is maintained by the pressure control of chlorine cooler inlet.

Recycle caustic is fed to electrolyser manifold through a caustic heat exchanger and then distributed to each cathode chamber. The recycle caustic flow rate is controlled by the flow controller installed in the caustic Feed line.

A two-phase stream of caustic solution and wet hydrogen gas overflows from each cathode chamber and is separated at the collection manifold equipped with electrolyser.

The caustic solution flows through the common header into the caustic recycle tank by gravity while the hydrogen gas is introduced into Hydrogen...
16.5 Gas Processing Section.

The hydrogen gas pressure is maintained by Pressure Control Scheme. To prevent an excessive positive pressure, a hydrogen vent stack is provided. This stack also serves as a gas purge system at the PLANT start up.

Upon leaving the caustic recycle tank, the caustic solution separates into two streams, the product stream to the Caustic Concentration Section and the recycle caustic stream to the electrolysers. The caustic heat exchanger heats or cools the recycled caustic to maintain the electrolyser operating temperature at 85 — 90°C.

The electrolyser caustic strength is monitored by the caustic density indicator, and normally kept at approximately 32 wt%, the optimum concentration for membrane performance, by controlling the pure water feed quantity into the recycled caustic stream.

During start-up, the caustic heat exchanger is used to warm the electrolyte in the electrolysers, accelerating to full current load attainment without excessive voltage. To detect abnormalities of electrolysers, electrolyser voltage and temperature monitoring systems are considered in the PLANT design.

16.6 BRINE DE-CHLORINATION

Depleted brine from Anolyte tank is taken to a Brine De-chlorination plant for de—chlorination because brine should be totally free from chlorine. Brine de-chlorination plant consists of packed tower where vacuum (600 torr) is maintained with the help of Steam Ejector.

Now Chlorinated brine is sprayed from top to the column and free chlorine is sucked from the top of the column and through cooler after cooling, it is sent to chlorine gas absorption section.

Dosing of Hydrochloric acid is done to reduce the pH of brine up to desired level before feeding it into de — chlorination tower.

Now brine, which is free from chlorine, is taken to de-chlorination tower & is again treated with Sodium Sulphite to remove the traces of any chlorine left because chlorine is very harmful for the complete system. Therefore at the inlet of return brine tank, brine is always tested for the presence of chlorine.
Electricity Tariff-2017 (Ceylon Electricity Board)

Customer Category I-3

This rate shall apply to supplies at each individual point of supply delivered and metered at 11,000 Volt nominal and above.

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Energy Charge (LKR/kWh)</th>
<th>Fixed Charge(LKR/month)</th>
<th>Maximum Demand Charge Per month(LKR/kVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak (18.30 – 22.30)</td>
<td>23.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day (5.30 – 18.30)</td>
<td>10.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-peak(22.30 – 05.30)</td>
<td>5.90</td>
<td>3,000</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Note: Electricity Tariff has not been revised by the CEB for the three years. For the purpose of calculation of Costing / Profit & Loss Forecast, previous price schedule as given in the above table was taken. There is Time of Day rates applicable with different unit rates for three time slots peak, off-peak and day. A weighted average rate is calculated and found to be LKR 11.19. For the purpose of costing, a higher value than the weighted average unit price is taken considering a near future price hike otherwise would result in misleading profit figures. It is also assumed that the plant is running on a constant production capacity throughout the day.

In addition there will be demand charge of Rs.1000 per kVA.

Electricity Cost

Production process has an Electrolysis process where large volume of electricity is consumed. Therefore electricity cost is a major operational cost. It is planned to operate the plant on full capacity during off-peak hours & to run at lower capacity levels during off-peak hours as described in the foregoing section. However when the capacity utilization reaches 100%, plant has to operate 100% capacity throughout 24 hours.

Electricity Cost Calculation

Electricity is supplied at different unit prices to the Industrial Consumers by the CEB depending on the time of the day electricity is being used. There is three time slots where unit prices are different as given in the below time slots,
Electricity Tarif of CEB (Time of Day)

<table>
<thead>
<tr>
<th>Time Slot</th>
<th>Unit Price (LKR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.30am-6.30pm</td>
<td>10.25</td>
</tr>
<tr>
<td>6.30pm-10.30pm</td>
<td>23.50</td>
</tr>
<tr>
<td>10.30pm-5.30am</td>
<td>5.90</td>
</tr>
</tbody>
</table>

Plant is planned to be run on Full capacity during lowest unit price hours of the day (10.30pm to 6.30am), while plant will be operated at 50% capacity during peak hours (6.30pm to 10.30pm) & at 85% capacity during daytime from 5.30am to 6.30pm

Cost of electricity can be optimized with above plant operation schedule.

Electricity cost calculation for the above schedule,

<table>
<thead>
<tr>
<th>Time Slot</th>
<th>Unit Price (LKR)</th>
<th>No of hours in each time slot</th>
<th>Production Rate per Hr (MT)</th>
<th>Plant Utilization</th>
<th>Total Production (MT)</th>
<th>Cost of Electricity (LKR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.30am-6.30pm</td>
<td>10.25</td>
<td>13</td>
<td>1.042</td>
<td>85%</td>
<td>11.51</td>
<td>306,753</td>
</tr>
<tr>
<td>6.30pm-10.30pm</td>
<td>23.50</td>
<td>4</td>
<td>1.042</td>
<td>50%</td>
<td>2.08</td>
<td>127,292</td>
</tr>
<tr>
<td>10.30pm-5.30am</td>
<td>5.90</td>
<td>7</td>
<td>1.042</td>
<td>100%</td>
<td>7.29</td>
<td>111,854</td>
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<tr>
<td>Cost per day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20.89</td>
<td>545,898</td>
</tr>
<tr>
<td>No of days per yr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>330</td>
</tr>
<tr>
<td>Total Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>180,146,484</strong></td>
</tr>
</tbody>
</table>
14. Conclusion and Recommendation

Main factor which restricts the production capacity at the initial stage of operation is control of surplus chlorine produced in production of caustic soda. However once project is launched and hydrochloric acid is available in abundance at a low price as a raw material for downstream industries, market for hydrochloric acid will be increased.

It is recommended to set up caustic soda plant with a base capacity of 25 Ton per day in the initial phase with infra-structure designed for 50 Ton per day. Plant will meet the entire country demand for chlorine, hydrochloric acid and sodium hypochlorite. It is expected that the hydrochloric acid market will grow once HCl will be available in abundance at a lower price. It is proposed to enhance the base capacity to 50 Ton per day at second phase of development, to be initiated after 4 years of operation at initial capacity.

There is substantial growth potential in the caustic soda demand and hydrochloric acid demand. Downstream chemical poly aluminium chloride (PAC) produced using hydrochloric acid is used in the drinking water purification with an increasing demand. Poly aluminium chloride is a better substitute for alum for the drinking water purification.

This project will also ensure supply of chlorine requirement for drinking water purification & thereby ensuring safe drinking water for the country.