Mono-Ethylene Glycol Project at Paradip

1. INTRODUCTION:

The objective of the project is the production of fibre grade Mono Ethylene Glycol (MEG) for merchant sale. Raw Material for MEG production is ethylene and oxygen. Ethylene is recovered from FCC off gas via Ethylene Recovery Unit and Oxygen from air through Air Separation Unit.

Mono Ethylene glycol in its pure form, it is an odorless, colorless, syrupy liquid with a sweet taste. Mono Ethylene glycol is produced from ethylene, via the intermediate ethylene oxide. Ethylene oxide reacts with water to produce ethylene glycol according to the chemical equation. The major byproducts are the diethylene glycol, triethylene glycol, and poly glycol.

Monoethylene glycol (MEG) is an important raw material for industrial applications. A primary use of MEG is in the manufacture of polyester (PET) resins, films and fibers. In addition, MEG is important in the production of antifreezes, coolants, aircraft anti-icer and deicers and solvents.

Diethylene glycol is used in the manufacture of unsaturated polyester resins, polyurethanes, and plasticizers. Triethylene glycol (TEG) is widely used as a dehumidifying agent for air and natural gas. TEG is often used to make chemical intermediates such as plasticizers and esters.

2. MATERIAL BALANCE:

<table>
<thead>
<tr>
<th>INPUT</th>
<th>KTA</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCC Off Gas</td>
<td>454.0</td>
<td>From FCC unit</td>
</tr>
<tr>
<td>Oxygen</td>
<td>188.0</td>
<td>From Air Separation Unit</td>
</tr>
<tr>
<td>Total</td>
<td>642.0</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>OUTPUT</th>
<th>KTA</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEG</td>
<td>332.0</td>
<td>For merchant Sale</td>
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<tr>
<td>DEG</td>
<td>23.0</td>
<td>For merchant Sale</td>
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<tr>
<td>TEG</td>
<td>1.0</td>
<td>For merchant Sale</td>
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<tr>
<td>Poly-glycol</td>
<td>1.0</td>
<td>Internal use as Fuel Oil</td>
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<tr>
<td>C3+ streams</td>
<td>39.0</td>
<td>LPG Pool</td>
</tr>
<tr>
<td>Fuel Gas</td>
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<td>Internal use as fuel gas</td>
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<tr>
<td>Total</td>
<td>642.0</td>
<td></td>
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</table>

3. PROJECT DESCRIPTION:

The project consists of the followings:

A. Ethylene Recovery Unit
B. Mono Ethylene Glycol Unit
C. Utilities & Offsites
A. **Ethylene Recovery Unit (ERU)**

Capacity : 180 KTA Ethylene production

**Process Flow Diagram of ERU**

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**Process Description of ERU:**

The purpose of the Low Pressure Ethylene Recovery (ER) Unit is to remove impurities found in the FCC offgas and to recover the ethylene for use in the downstream EB/SM units to make styrene monomer.

The ER Unit is divided into the following areas and sub-areas:

- **Feed Treatment**
  1. DGA Wash system
  2. Caustic/Water Wash
  3. Oxygen Converter
  4. Drying and Treating

- **Distillation Area**
  1. Offgas Chilling and Demethanizer
  2. Deethenizer
  3. Binary Refrigeration

- **Feed Treatment Area**

  The contaminants in the FCC offgas will be removed before the feed is processed in the downstream distillation area. The feed is first sent to the lower bed of the Caustic/Water Wash Tower where the H2S in the feed is removed and the amount of CO2 is reduced. Next the feed goes through a Chloride Treater to remove chlorides. After the Caustic Tower and Chloride Treater and adsorber the feed goes to the Oxygen Convertor where Oxygen and Nitrogen are removed and di-olefins converted to olefins.

  The offgas from the Oxygen Converter is routed to the upper bed of the Caustic/Water Wash Tower to remove any remaining acid gases. The offgas is then chilled before being sent to the Dryer/Treater to remove the water, mercaptans, ammonia, and amines. Finally, the feed goes through a Mercury Adsorber where the mercury is removed.
Distillation Area

The feed is then sent to the FCC Offgas Chiller, located in the Cold Box, where a binary refrigerant is used to chill the feed. After being chilled it is then sent to the Demethanizer. The Demethanizer is provided with an intercooler using binary refrigerant to minimize the ethylene losses. In the Demethanizer the FCC offgas fed into the lower part of the tower is contacted against a side draw stream from the Deethylenizer, which enters at the top of the tower. The overhead stream from the Demethanizer is used as regeneration gas for the Dryer/Treaters and then sent to OSBL to be used as refinery fuel gas.

The Demethanizer bottoms stream is sent to the Deethylenizer. The Deethylenizer overhead is fully condensed using binary refrigerant and produces 99.95 mol % ethylene. The liquid product is then pumped, vaporized in the FCC Offgas Chiller to recoup duty for the refrigeration system, and then sent to the MEG Unit. The bottoms stream is sent to OSBL as C3+ Product, to the offspec LPG system. A side draw from the Deethylenizer is sent back to the top of Demethanizer as a wash liquid, with a portion of the side draw recovered as ethane product.

A binary refrigerant consisting of ethylene and propylene is utilized to provide the refrigeration at the necessary levels for the process users.

B. Mono Ethylene Glycol Unit (MEG Unit)

Capacity: 332 KTA MEG production

Process Flow Diagram of MEG Unit

EO REACTION, EO AND CO SCRUBBING SECTION

Ethylene, oxygen, and methane/nitrogen ballast gas enter from battery limits and are mixed with lean cycle gas before entering a preheating unit (the Gas-Gas Exchanger). The gas mixture flows from the Gas-Gas Exchangers to the EO
Reactor/Gas Coolers where about 9.6% of the ethylene is converted per pass. The ethylene to ethylene oxide selectivity is 83.4% at start-of-run (SOR). The reactors produce ethylene oxide. The ethylene oxide is scrubbed from the EO Reactor/Gas Coolers exit gas using lean cycle water and the rich cycle water is sent to the EO Stripping Section. The (scrubbed) cycle gas is sent through the CO₂ Contactor Section of the Wash Tower to remove carbon dioxide made in the EO Reactor/Gas Coolers. The CO₂ -lean gas is then recompressed back to the EO reactor/Gas Coolers. Boiling water on the shell side of the multi-tubular reactors removes the heat of reaction. Water circulation through the shell side of the reactors is by thermosyphon action. The steam-water mixture from the reactors shellside is sent to steam drums where make-up boiler feed water is preheated and steam is separated from water and sent to the 21 kg/cm g steam header.

- **CO₂ REMOVAL SYSTEM SECTION**
  The rich carbonate solution from the Carbonate Solution Exchanger (EO and CO₂ Scrubbing Section) is regenerated at essentially atmospheric pressure using stripping steam. The regenerated lean carbonate solution is returned to the CO₂ Contactor Section of the Wash Tower (EO and CO₂ Scrubbing Section) for CO₂ absorption.

- **EO STRIPPING AND EO REABSORPTION SECTION**
  Rich cycle water containing ethylene oxide in solution is preheated before entering the Stripping Column where ethylene oxide is stripped out. The lean cycle water is then pumped through a series of heat exchangers where the water is cooled prior to being returned to the Scrubber Section of the Wash Tower (EO and CO₂ Scrubbing Section). A bleed stream is taken and sent to the glycol unit to purge the glycol made in the cycle water loop. The ethylene oxide in the overhead vapor from the Stripping Column is reabsorbed by contact with cooled process water in the Reabsorber. The overhead from the Reabsorber is compressed back into the cycle gas system by the Reclalm Compressor while the bottoms are sent to the Glycol Feed Stripper (Glycol Reaction Section).

- **GLYCOL REACTION AND GLYCOL EVAPORATION SECTION**
  Ethylene oxide solution from the Re-absorber is sent to the Glycol Feed Stripper for removal of CO₂. The CO₂ -free stream is then preheated and fed to the Glycol Reactor. The reactor effluent is fed into the first stage of a Seven Effect Evaporator System. The cycle water bleed from the cycle water and the MEG Column Condenser blow down are treated in a Cycle Water Treating Unit and then used in the evaporator system as reflux. The condensate from the reboilers of the evaporators is used to preheat the feed to the Glycol Reactor, and is then sent to the Recycle Water Tank. The overhead from the Fifth Effect Evaporator (extraction steam) is used in the Regenerator Extraction Re-boiler. The overhead vapor from the Sixth Effect Evaporator is used as stripping steam for both the Stripping Column and Glycol Feed Stripper and also is used to reboil the Sixth Effect Evaporator bottoms and to preheat the feed to the Glycol Reactor. The overhead from the Vacuum Effect Evaporator is condensed with a portion returning to the column as reflux, another portion is used as reflux for the Drying Column (Glycol Drying Section) and the remainder is sent to the Recycle Water Tank. The concentrated glycol from the Vacuum Effect Evaporator is pumped to the Drying Column (Glycol Drying Section) for removal of the remaining water.

- **GLYCOL DRYING AND GLYCOL PURIFICATION SECTION**
  The crude wet glycol is dried by vacuum distillation in the Drying Column. The Drying Column bottoms are fed to the MEG Column where fiber grade mono-ethylene glycol product
is taken as a side stream product near the top of the column. The product is cooled and stored in the MEG Rundown Tanks for subsequent pumping to OSBL storage.

The MEG Column bottoms are sent to the MEG Splitter where the remaining MEG is removed from the heavier glycols and recycled back to the Vacuum Effect Evaporator. The MEG Splitter bottoms are sent to the DEG Column (DEG and TEG Purification Section) for DEG and TEG separation.

- **DEG AND TEG PURIFICATION SECTION**
  Heavy glycols from the MEG Splitter bottoms are distilled in the DEG Column where the diethylene glycol (DEG) product is taken overhead. The DEG product is cooled and stored in the DEG Rundown Tanks for subsequent pumping to OSBL storage. The DEG Column bottoms are then sent to the TEG Column for further distillation where the triethylene glycol (TEG) product is taken overhead. The TEG product is cooled and stored in the TEG Rundown Drums for subsequent pumping to OSBL storage. The TEG Column bottoms, containing the poly-glycols, are stored in the PEG Drum.

C. **Utilities & Offsites**

Utilities section consists of a new Cooling Water system. Other utilities i.e. steam, electricity, DM water, compressed air will be supplied from existing refinery.

Offsite section consists of Air Separation Unit for oxygen supply to MEG unit, storage tanks/vessels for finished products i.e. for MEG, DEG, TEG and poly glycol, Horton Sphere for storage of liquid ethylene, product dispatch system and flare system.

To control SO\(_2\) emission on account of MEG project, a new flue gas desulphurization unit is to be installed. Effluent generated from the process units is to be routed to existing Effluent Treatment Plant of the refinery.