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Treatment of Ethane-Propane in a Petrochemical Complex

Apoorva Vinayak Rudra
Department of Chemical Engineering, Institute of Chemical Technology, Mumbai, India
vinayak_blazer@yahoo.com

Abstract— A Petrochemical complex is responsible for producing various petrochemicals. It is made up of various fragments that work in synchronization with each other. This paper focuses on treatment of ethane-propane in a petrochemical complex after recovery from natural gas. Some of the important fragments are the Gas Sweetening Unit (GSU), the (C2\C3) Recovery Unit, and the Gas Cracker Unit (GCU). The GSU uses a solvent for removing acid gases like CO_2 in the natural gas by chemical absorption. First counter current absorption of the gas with a solvent like DEA takes place and then its further treatment in the regenerator column to strip off the CO_2. The 'sweetened' gas from the GSU forms the feedstock to the C2\C3 Recovery Unit where cryogenic conditions prevail and if the CO_2 component of the gas is not removed, it will freeze at such low temperatures. The ethane-propane is cracked in the GCU.

Keywords— Cryogenic, DEA, Petroleum, Sweetened Gas

I. INTRODUCTION

A petrochemical is a chemical product derived from petroleum. With the increase in the need for petrochemicals in our daily lives as well as our industrial aspects, there is a need for production of petrochemicals in a proper and most optimized manner. Some important petrochemicals are ethylene, propylene, butadiene, benzene, toluene, and xylenes etc. Benzene is a raw material for dyes and synthetic detergents, and benzene and toluene for isocyanates.

Some petrochemical complexes recover ethane-propane (C2\C3) from natural gas coming from a pipeline for producing petrochemicals. Conversion of ethane-propane (otherwise used as fuel) from natural gas will give tremendous value addition. The ethane-propane is recovered from the natural gas in the Gas Processing Unit (GPU) and is cracked in the Gas Cracker Unit (GCU) to produce ethylene and propylene. Ethylene is converted into final products- HDPE (High Density Polyethylene) and LLDPE (Linear Low Density Polyethylene) in the two polymer units.

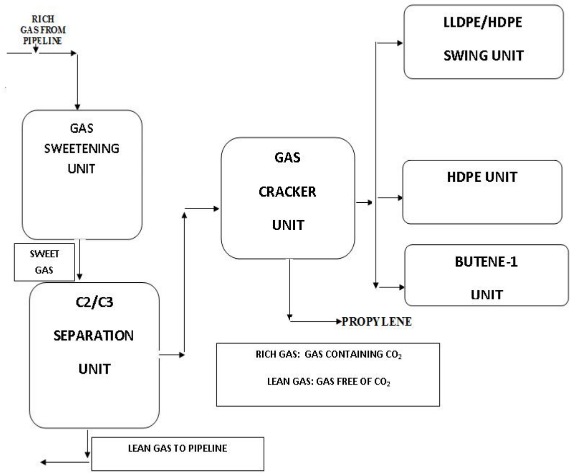

Fig 1. Petroleum Complex Configuration

II.PRODUCTS FORMED

MAIN PRODUCTS
HDPE
LLDPE\HDPE
OTHER PRODUCTS

TABLE I

PRODUCTS	END USE
propylene	Feedstock poly
Butene-1	Copolymer for
C4 mix	Lube oil,
Pyrolysis gasoline	Fuels, blended
Furnace oil	Fuels
C5 and gasoline mix	Fuels, SBP solvent
Spent alumina	Refractories

III. STAGES

III.A. GAS PROCESSING UNIT (GPU)

There are two important fragments of this unit:

- Gas Sweetening Unit (GSU)
- C2\C3 Recovery Unit

III.A.1 GAS SWEETENING UNIT

CO_2 present in the feed gas is removed in this by using DEA (Diethanolamine) as a solvent. The unit is designed to handle the feed gas. The term 'Sweetening' means removal of acid gases like H_2S and CO_2 and H_2S .This gas forms the feedstock to the C2\C3 Recovery Unit where cryogenic conditions prevail and if the CO_2 component of the gas is not removed, it will freeze at such low temperatures. After sweetening, gas is sent to the C2\C3 unit.

PROCESS DESCRIPTION

1. ABSORPTION SECTION

The raw gas is treated in two parallel high pressure Absorbers. The gas is fed to the Absorber Columns at 52 kg /cm^{2}a and 30^o C. This gas is treated with DEA solvent (40 wt %) which is fed from the top of the column. The Absorber Column contains 30 Valve Trays.

The CO_2 in the gas reacts with with Amine to form Amine Carbonate.

$$CO_2 + 2R_2NH \longrightarrow R_2NCOO^- + R_2NH_2^+$$

But CO_2 can also react with water or hydroxyl ions to form carbonic acid or bicarbonate ions.

1. $CO_2 + H_2O \longrightarrow H_2CO_3$

2. $CO_2 + OH^- \longrightarrow HCO_3^-$

Then these acids react with amine to form amine bicarbonate. The treated gas leaves from the column top at 45^o C and contains less than 50 ppmv of CO_2.

2. TREATED GAS WATER WASH AND COOLING

The treated gas from the Absorber Column is counter – currently washed with water in Water W ash Column equipped with pall rings to remove the DEA carried over with the gas. The DEA solution in solution in water is removed from the bottom of this column and sent to the Rich Amine Flash Drum. The treated gas is cooled to 40^o C and leaves the Unit at 50 kg /cm^{2}a.

3. RICH AMINE CIRCUIT

The rich amine from the Absorber bottom and the Water Wash Column are sent to Rich Amine Flash Drum. The Rich Amine Flash Drum is operated at 6.5 kg /cm^{2}a and 70^o C. Most of the hydrocarbons co- absorbed in DEA solution are desorbed in this drum and are routed to the plant fuel gas system.

4. AMINE REGENERATION

The rich amine solution from the Flash Drum enters the Regenerator Column through the Rich / Lean Exchanger at 110^o C. In the Regenerator the solvent DEA is stripped off CO_2 using LP steam in the Column Reboilers. This Column has 21 valve trays. The top two trays are used to minimize DEA carryover with the CO_2.

This Column operates at 2.0 kg /cm^{2}a. The top temperature is 97^o C and the bottom temperature is around 126^o C. The Lean Amine is withdrawn from the bottom of the column and is sent to storage after being cooled to 45^o C in Rich / Amine Exchanger and then by cooling water.

Vapors from the Regenerator top are condensed in the Regenerator Overhead Condenser and taken into Regeneration Reflux Drum.

The uncondensed gases mainly CO_2 (acid gas) are vented to atmosphere at a safe location and the condensed liquid is pumped back as reflux to the column.

5. AMINE STORAGE

The lean amine from Regenerator is sent to Amine Storage Tank from where it is pumped to the Absorbers. The Amine Storage Tank is blanketed with Nitrogen to prevent solvent degradation with Oxygen.

6. AMINE FILTRATION

A stream of stored amine solution is continuously sent to the filtration package by amine filtration pump. DEA solvent filtration is required to remove all the dissolved hydrocarbons, scales & solvent degradation products that can cause corrosion and foaming. There are basically three levels of filtration:

- Activated Carbon Filter which removes corrosion products & Hydrocarbons.
- Cartridge filter which removes any Carbon Particles.
- Pre-coat Filter consisting of cellulose.

7. AMINE DRAIN RECOVERY

All the solvents are recovered in an underground Amine Sump Drum. The solvent recovered in this drum is recycled to the Solvent Circuit by a submerged pump.

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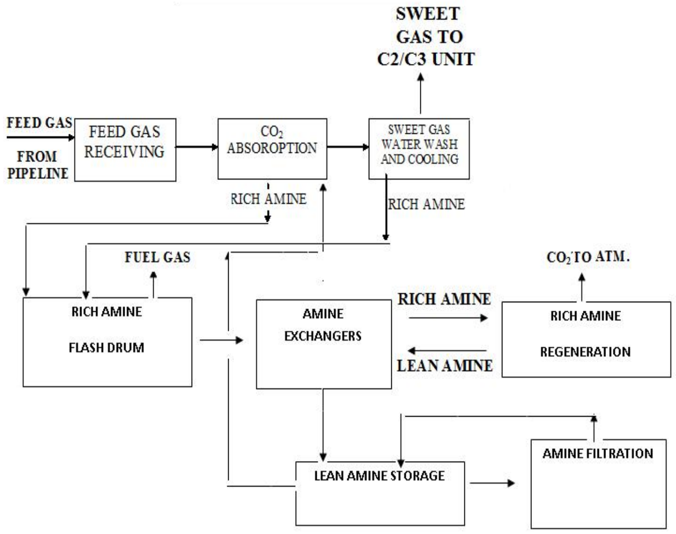
Fig 2. Block diagram of Gas Sweetening Unit



III.A.2 C2/C3 RECOVERY UNIT

In the plant, C2/C3 fraction of the feed gas is recovered under cryogenic conditions by Turbo-Expander process. The C2/C3 product from this unit forms the feedstock for the Gas Cracker Unit. The C2/C3 recovered from Natural Gas in this unit is used to produce ethylene.

The process comprises of the following sections:

1. FEED GAS COMPRESSION

The Sweetened Gas is received from the Gas Sweetening Unit at 50 kg /cm^{2}a & 40^o C. In the Feed Gas Knock Out Drum where the entrapped liquids are removed. The gas is now compressed to 55 kg /cm^{2}a in a Feed Gas Expander Compressor.

2. FEED GAS DRYING / REGENERATION

The Compressed gas is cooled down to 37^o C using cooling water in Feed Gas Compressor Discharge Cooler and further down to 18^o C by the outgoing Lean Gas in the Feed / Lean Gas Exchanger. The condensed mixture from the gas is removed in Moisture Separator. The gas is now saturated with water that is removed in a Dryer to a Water Dew Point of -100^o C using molecular sieves as desiccants.

There are two Dryers out of which one is in drying mode and the other is either a standby or in regeneration mode. The drying period is around 12 hours and the regeneration is also 12 hours.

A part of the Lean Gas from the first stage discharge of the Lean Gas Compressor is heated to 320^o C in a Gas Fired Heater and this hot gas is used for regeneration of the Dryers.

3. FEED GAS CHILLING / SEPARATION

After drying the feed gas is taken to the Demathaniser Bottom Reboiler where it is further cooled to around 5^o C to 7^o C after supplying the Column Reboiler duty.

The Feed Gas then enters the Feed Gas Chiller #1 where it is cooled down to – 32^o C by the Separator 1 and 2 liquids and the Lean Gas. The gas is further chilled down to – 38^o C in the Demathaniser Side Reboiler.

The Gas is chilled in the Feed Gas Chiller 1 to about – 55o C to – 60o C. This partially condensed Feed Gas at this stage is taken to the Separator 1 where the condensed liquid is separated and sent to Chiller 1 for Cold Recovery. This liquid is then fed to the Demathaniser Column.

The uncondensed vapors from the Separator 1 are cooled to – 68^o C by the outgoing Lean Gas in the Feed Gas Chiller 2. These vapors are now taken to Separator 2 where again the condensed liquid is separated. Cold from this liquid is recovered in Feed Gas Chiller 1. It is then mixed with the Separator 1 liquid and this is fed to the Demathaniser Column on Tray 18.

4. FEED GAS EXPANSION

The Overhead gas from Separator 2 is expanded isoentropically in the Feed Gas Expander to around 22 kg /cm^{2}a and the temperature of the gas drops to 98^o C. Due to this chilling, there is further condensation of the gas. This Vapor Liquid mixture is fed to the Demathaniser Column on the 8th tray. The work available from the isoentropic expansion of the Separator 2 vapor is used to compress the feed gas

5. FRACTIONATION

This section consists of a Demathaniser Column which serves to recover C2-C3 product from

I. Separator 1 and 2 liquids received at -68^o C
II. Feed Gas Expander overheated vapors received at -98^o C.

This column separates almost all the Methane from the Gas. It consists of 36 valve trays and one chimney tray for supplying feed to Side Reboiler. The Column Reboilers chill down the Feed Gas and in turn recover reboiler duty.

The Overhead vapors are chilled from – 98^o C to – 102^o C and condensed in the Demathaniser Overhead Condenser by the cold gas from the Demathaniser Overhead Expander outlet (-117^o C). The Demathaniser overhead vapor is expanded from 21.5 kg /cm^{2}a and due to this the gas is chilled to – 117^o C.

This cold Methane is the major source of refrigeration in the unit.The bottom product from the Demathaniser Column is the C2-C3 product, which is pumped as feed to Cracker Unit or sent to Storage. The recovery of C2 is around 90%.

6. LEAN GAS COMPRESSION

The lean gas after giving away its cold to a series of exchangers get heated to 25^o C to 30^o C and is first compressed from 10 kg /cm^{2}a to 12 kg /cm^{2}a in the Demathaniser Overhead Expander Compressor is further compressed to 55 kg /cm^{2}a in a 2- stage gas turbine driven Lean Gas Compressors. It is cooled to 40^o C and sent back to the pipeline. About 36 Ton/hr of Lean Gas is drawn from first stage discharge of the Lean Gas Compressor for Dryer Regeneration. This gas is then compressed to 55 kg /cm^{2}a in a Steam Turbine driven Residue Gas Compressor and is then sent to the Lean Gas Compressor Discharge Header.

7. C2/C3 STORAGE

8 spheres of 15 m diameter having nominal activity of 1500 m^3 are provided in off sites area for storage of C2/C3. Normally 90% of the C2/C3 produced will be supplied directly from the GPU TO GCU as feed. A slip stream of around 10% of C2/C3 will be sent to storage and same quantity of C2/C3 will be pimped back from storage to GCU. In case GPU is not in operation, entire quantity of C2/C3 will be supplied from storage.

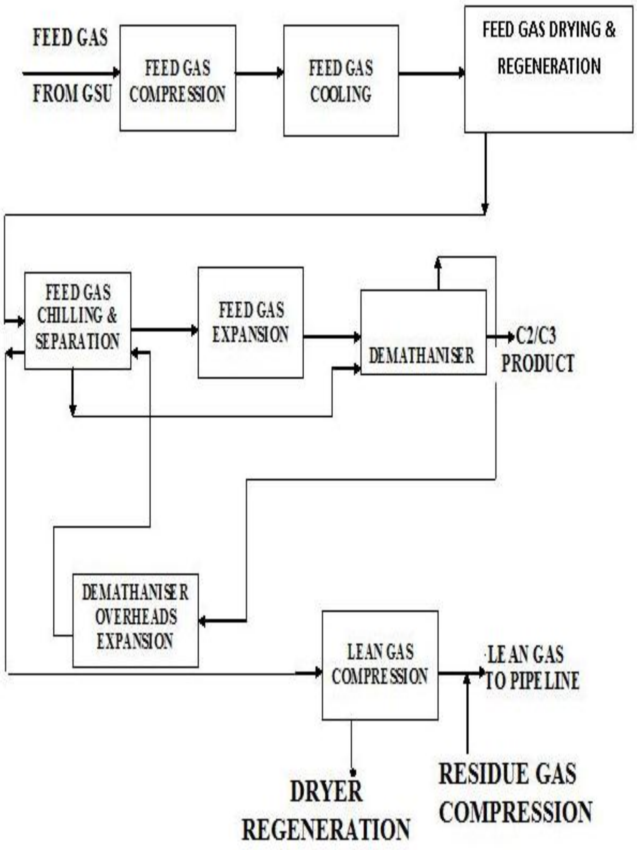


Fig 3. Block Diagram of C2/C3 Unit

III .B. BASIC FUNCTION OF GAS CRACKING UNIT

The breaking of a molecule to yield more useful products is called cracking. Cracking requires high temperature to initiate it and is endothermic. This heat is supplied by the direct firing of fuel gas in the furnace .This unit can be broadly divided into two sections namely Hot and Cold section. The Hot section comprises of feed vaporization, cracking furnaces, water quench, cracked gas compression, caustic wash and dehydrators. The Cold section comprises of the Demathaniser and the downstream separation facilities. After cracking, ethylene, propylene and other useful products are recovered and sent to various sections for further processing.

IV CONCLUSION

This paper proposes a method for the recovery of various petrochemicals (from ethane-propane mixture) which play a vital role in our daily as well as our industrial aspects.

In this work, the methods incorporated for the recovery and processing of petrochemicals result in optimization of the available resources with increased benefits.

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REFERENCES

[1] Chemical Engineering Oil Handbook of Petroleum Processing.

[2] Chemistry of Petrochemical Processes (Second Edition)By *Sami Matar and Lewis F. Hatch*

[3] "Engineering Data Book," 11th Ed., Gas Processors Suppliers Association, Tulsa, 1998

[4] Kister, H.Z., "Distillation Operation," McGraw-Hill Cos., New York,1989

[5]Coulson and Richardson’s “Chemical Engineering”,Fifth edition,Volume 2

[6] UPPC Project Configuration manual of GAIL pata