Processing of Hydrocarbons from Producing Wells to Storage Tanks in Oil and Gas Industry

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Abstract: Hydrocarbons undergo a multitude of processing steps from the time they are extracted from earth in the form of crude oil and gas to the time they are available to end users. Crude oil is processed in units such as visbreaker, bitumen blowing, fluidized catalytic cracking, and crude distillation. Removal of mercaptans from oil and gas by oxidation is done through a proprietary process called Merox. Storage and distribution of refined oil and gas and its byproducts such as asphalt is done via pipeline and shore transfers and shipment using transfer pumps and tanks. This paper makes an attempt to discuss this briefly.

Keywords **- Crude distillation, visbreaker, bitumen blowing, fluidized catalytic cracking, liquefied petroleum gas (LPG) amine treatment, LPG Merox, gasoline Merox, aviation turbine fuel (ATF) Merox, flare system, propylene recovery, transfer pump and tank farm, pipeline or shore transfers, LPG storage and shipments, asphalt storage and shipments, oil wharf, marine or offshore operations, inner harbor and offshore tanker terminal.**

I. INTRODUCTION

Crude is a highly complex mixture of hydrocarbons and primarily contains hydrogen and carbon. The main types of hydrocarbons present in crude petroleum are paraffins (CnH2n+2), olefins (CnH2n), naphthenes (CnH2n) and aromatics (CnH2n-6), although diolefin (CnH2n-2) and other cyclic series hydrocarbons may find themselves in some crudes. Small quantities of other elements, which are considered as impurities like sulphur, nitrogen, oxygen and some metal traces are also present in crude oil. Certain sulphur compounds known as mercaptans impart undesirable odour and corrosiveness to light crude fractions. Hydrogen sulphide, water and common salt are also undesirable constituents of crude oil, which affect the efficiency of the operations and spoil the refinery equipment. Among the various steps involved in crude oil processing are crude distillation, visbreaker breaking, bitumen blowing, fluidized catalytic cracking, and Merox. Merox is a chemical treatment of petroleum distillates to remove mercaptans or to convert mercaptans to disulphides. This process is based upon the ability of a catalyst to promote the oxidation of mercaptans to disulphides using air as the source of oxygen. Oil movement and storage is an important wing of refinery operations and is responsible for receiving crude oil, pumping them to the units, receiving finished and intermediate products into storage tanks, blending and for finally transferring the finished products to end users.

II. CRUDE PROCESSING

2.1 Crude Chemistry

Crude oil is one of the two major fossil fuels on earth, the other being coal. It is the main and cost effective energy source today. Crude oil varies widely in appearance and consistency from country to country and from field to field. However, all crude oils consist essentially of hydrocarbons. Crude oils are classified based on the types of series of hydrocarbons present in crude (paraffin, asphalt, or mixed), based on the sulphur content (high or low), based on API gravity or density (high or low). Crudes may also be classified mainly into indigenous and imported. Bombay High, Ravva are the main indigenous crudes. Some of the imported crudes are Qua Iboe, Labuan, Miri Light, Kuwait, Upper Zakum, and Arab Mix.

Hydrocarbons present in crude oil

Hydrocarbon	Percentage
Gas	1 – 4
Naptha/straight run gasoline	4 – 12
Distillates(kerosene-diesel)	10 – 18
Gas oil	14 -22
Lube oil distillate	16 – 26
Residuum (reduced crude, heavy fuel, asphalt etc)	26+

Products from crude oil

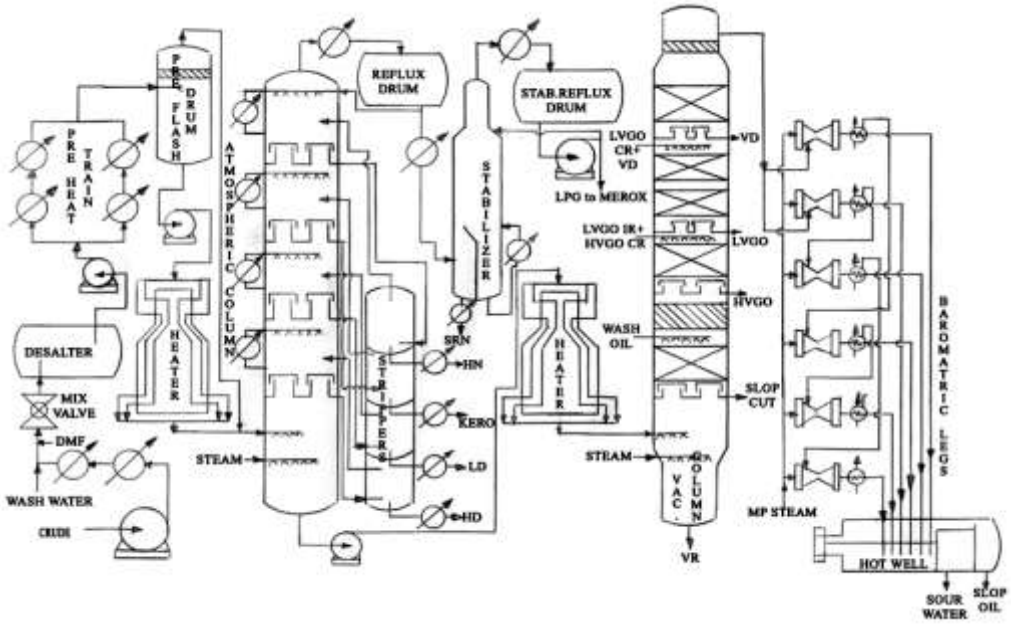
Liquid Distillates	Middle Distillates
Propylene	Mineral turpentine oil (MTO)
Liquefied petroleum gas (LPG)	
Low aromatics naphtha (LAN)	
High aromatic naphtha (HAN)	
Motor spirit (petrol)	

2.2 Crude Oil Pretreatment (Desalting)

Crude oil often contains water, inorganic salts, suspended solids, and water-soluble trace metals. As a first step in the refining process, to reduce corrosion, plugging, and fouling of equipment and to prevent poisoning the catalysts in processing units, these contaminants must be removed by desalting (dehydration).

2.3 Crude Distillation

This process can be broadly classified into atmospheric and vacuum sections. In the atmospheric section the following are produced: Overheads, heavy naphtha, aviation turbine fuel (ATF)/kero, MTO, light diesel, jute batching oil (JBO)-I, JBO-II, heavy diesel. In the vacuum section the following are produced: Top diesel, light vacuum gas oil (LVGO), heavy vacuum gas oil (HVGO), slop, short residue.



Crude distillation unit

2.4 Visbreaking

Visbreaking unit is a non-catalytic thermal process that converts atmospheric or vacuum residues to gas naphtha distillates and tar visbreaking reduces the quality of cutter stock required to meet fuel oil specifications while reducing the overall quantity of fuel oil produced.

2.5 Bitumen Blowing

Bitumen is produced from vacuum residue, which is blown by hot air in the bitumen blowing unit. Biturox is a proprietary process for bitumen blowing with the following advantages.

- Best possible oxygen utilization and hence lesser quantity of air requirement.
- Optimum temperature control by water injection along with air.
- Reduced residence time and hence smaller reactor volume.
- Lesser coking tendency due to more effective air distribution and hence of maintenance.
- Flexibility for producing different grades of Bitumen.

2.6 Fluidized Catalytic Cracking

Cracking is a phenomenon by which large oil molecules are decomposed into small lower boiling molecules. At the same time certain of these molecules, which are reactive, combine with one another to give even large molecules than those present in the original stock. The more stable molecules leave the system as cracked gasoline and reactive ones polymerize forming fuel oil and even coke.

III. MEROX

Merox process uses catalysts to treat refinery streams containing mercaptans. The mercaptan rich streams are contacted with aqueous caustic in the presence of Merox catalyst. The mercaptans are either extracted from hydrocarbon stream and oxidized to disulphide in a separate section of the unit or are oxidized directly to disulphides, which then remain in the products. The choice of Merox process type is dependent on the feedstock and the product specification. The overall chemical reaction can be written as,

$$RSH + {}^1/_4O_2 \rightarrow {}^1/_2RSSR + {}^1/_2H_2O$$

Where R is a hydrocarbon chain, which may be straight, branched or cyclic. These chains may be saturated. As the molecular weight of the mercaptans increases, its solubility in the alkaline solution decreases, and as chain branching increases, solubility decreases. The mechanism of mercaptan extraction, regeneration can be illustrated by the following equations,

$$RSH\ (Oil) + NaOH(aq) \rightarrow NaSR(aq) + H_2O$$

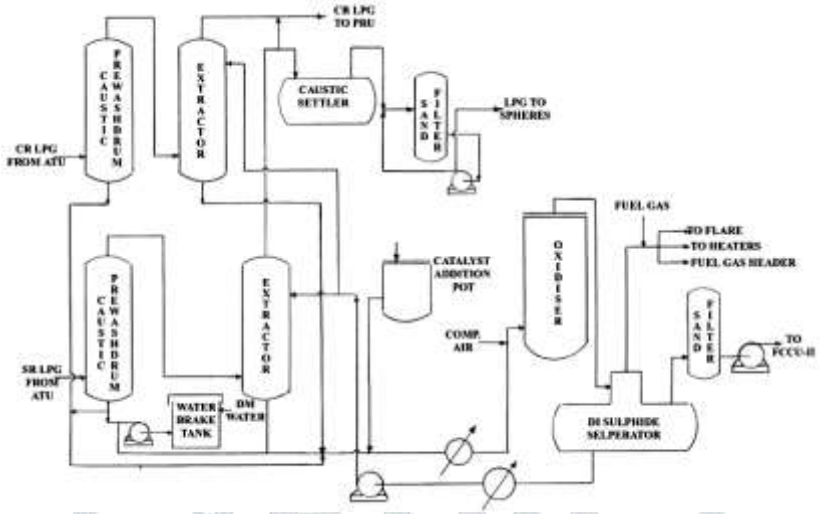
$$NaSR + {}^1/_4O_2 + {}^1/_2H_2O \rightarrow NaOH + {}^1/_2RSSR\ (Regeneration)$$

3.1 LPG Amine Treatment

H_2S and other sulphur compounds are normally present in some concentration in LPG stream. H_2S gas saturated with water vapour is highly corrosive to equipment. To remove H_2S from LPG, amine treatment facilities are provided.

3.2 LPG Merox

Virgin (straight run) LPG and cracked LPG streams contain lots of H2S (in the form of mercaptans) having offensive odour. In the LPG Merox unit, the mercaptans thus present in this LPG are removed by the way of extraction and thus the sulphur content of the treated product LPG is reduced. A strong aqueous alkali solvent, caustic (NaOH) is used for this extraction process, as mercaptans of lower molecular weight are soluble in caustic solution.



LPG Merox unit

3.3 Gasoline Merox

Gasoline Merox is conceived to convert the highly objectionable mercaptans to less objectionable disulphides, which remain in product gasoline; there is no reduction in the total sulphur content. Merox sweetening is applied to distillates containing mercaptans, which cannot be more on less completely removed by caustic extraction.

3.4 ATF Merox

The ATF Merox unit is designed to sweeten ATF stock from crude distillation units, having mercaptans level of around 300 ppm (wt%) to less than 10 ppm. These mercaptans are not susceptible to caustic and are oxidized to disulphides (odourless) in fixed bed reactor, using Merox reagent FB as catalyst.

3.5 Flare System

Flare system is provided for safe disposal of combustible, toxic gases, which are released from process plants during start up, shut down, normal operation or in case of emergency. Flare system is designed to burn at all times from the discharge of pressure relief systems and gases from depressuring of equipments. Any liquid hydrocarbon discharge into the flare header is separated in the knockout drums and pumped to slop tanks.

3.6 Propylene Recovery

Propylene is one of the product streams of fluid catalytic cracking unit. It is a mixture of propane, propylene, butane and butylene with some amounts of C2 and C5 hydrocarbons. Propylene constitutes about 26% by weight of cracked LPG. Propylene is recovered in a plant that consists of a pre-treatment section, C3-C4 splitter section, propane-propylene splitter section, and a post-treatment section.

IV. Oil Movement and Storage

Oil Movement and Storage (OMS) is an important wing of refinery operations and is responsible for receiving crude oil and catalytic cracking feed, pumping them to the units, receiving finished and intermediate products into storage tanks, blending and for finally transferring the finished products to end users. The activities of all movement and storage section include TPH (transfer pump house and tank farm); PLTs (pipe line transfers or shore transfers); LPG storage and shipments; asphalt storage and shipments; oil wharf, marine or offshore operations (inner harbor and offshore tanker terminal).

4.1 TPH and Tank Farm

Transfer Pump House (TPH) is responsible for entire offsite pumping and storage operations. Out of many storage tanks in a refinery some are floating roof type with the rest being fixed/cone roof type. Floating roof tanks, though complicated in construction, reduce breathing losses. Crude oil is received into large floating roof tanks directly from Offshore Tankage Terminal (OSTT).

4.2 Pipe Line Transfers

Although all petroleum transfers are pipe line transfers, this term is used essentially to indicate transfers to onshore terminals as against movements to offshore tankers.

4.3 LPG Storage

LPG is stored in Horton spheres provided in a refinery. They are provided with level indicators, high-level alarm, pressure safety valves, temperature and pressure gauges, and vent, drain and sample points. Remote operated valves (ROVs) are provided at the liquid inlet/outlet line of each sphere, vapour return line from loading area, recirculation line and minimum flow bypass lines which close automatically in case of fire through a security circuit.

4.4 Propylene Storage and Transfer

Propylene is stored in Horton spheres provided in a refinery. They are provided with level indicators, high-level alarm, pressure safety valves, temperature and pressure gauges, and vent, drain and sample points. Remote operated valves (ROVs) are provided at the liquid inlet/outlet line of each sphere, vapour return line from loading area, recirculation line and minimum flow bypass lines which close automatically in case of fire through a security circuit.

4.5 Asphalt Storage and Shipments

Bitumen or asphalt produced in the units is received into the intermediate storage tanks, which is then transferred to the storage tanks at Asphalt plant. The storage tanks are insulated and provided with steam coils to maintain tank temperature at around 140-160°C. Recirculation, truck loading and drum loading facilities are provided. Bitumen from storage tanks is cooled to 90°C in coolers using tempered water and pumped to overhead vertical tank. From there it is filled in drums by automatic filling machines using conveyor mechanism.

4.6 Marine Operations

The marine operations wing of OMS is responsible for coordinating offshore transfers of crude and petroleum products. This involves crude receipts into the refinery and product shipments out of refinery to other port locations. Oil wharf is part of the inner harbour. Unloading facilities are available for crude and LPG, while loading/unloading facilities are available for all finished products. Flexible hoses are connected between shipping lines and tanker with the help of derricks operated by air motors.

V. CONCLUSION

This paper has made an attempt at highlighting the steps involved in the processing of hydrocarbons from producing wells to storage tanks in oil and gas industry.

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