SUMMER INTERNSHIP PROJECT

HINDUSTAN PETROLEUM CORPORATION LIMITED
VISAKH REFINERY

VISAKHAPATNAM

A REPORT ON

- Study of PRIMARY, SECONDARY and TREATING Units.
- Study of Products Obtained.

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ACKNOWLEDGEMENT

With due respect, I express my deep sense of gratitude to the respected and learned guides of HPCL Visakh Refinery for providing their painstaking and untiring supervision. I am thankful to the Training Centre for giving me the opportunity to learn deeper inside the basics of crude refining.

My profound and sincere thanks to Mr. M J SATYA RAO(Chief Manager Training) who consented to be my project guide.

I am also thankful for giving me this opportunity to undertake a 4 week Technical Internship program (May 2nd - May 31st) .

Last but not the least, I am heartily thankful to all the Managers Engineers and all Shift Operators working under them to give me direction and valuable inputs on each & every sections of Petroleum Refining.

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PREFACE

In a system of education in which theory overrides practical knowledge, the importance of industrial training cannot be over estimated. It provides an insight about the industry, but most importantly bridges the gap between thought and action. I was fortunate to get the precious opportunity of vocational training under HPCL.

When a principle learnt in a classroom is borne out by practical experience, it creates a strange sense of excitement-akin to expectedly running into an old friend amongst crowd of strangers. All the pumps, compressors, turbines, valves, etc., pictures of whose pictures only have I have seen right before me.

During the training, I witnessed how problems were diagnosed and delivered. Many of the technicians had neither studied in major universities, nor were they merely implementing what their engineer-in-charge was suggesting.

They had been working hands-on for years and this had given them something like an intuitive feel for the work.

I am at last happy and proud to say that this duration of industrial training was a bonus time for me.

1. INTRODUCTION

A petrochemical industry basically converts petroleum and natural gas in useful products. Petroleum refinery use crude petroleum as a raw material and converts it into different products like petrol, kerosene, diesel, low-density oils, hydrocarbons like propane and propylene, butane and butylene, pentane, hexane, toluene, benzene, and other products like tar, lubricants base, etc.

HPCL REFINERY VISAKHAPATNAM

2. HPCL – COMPANY PROFILE

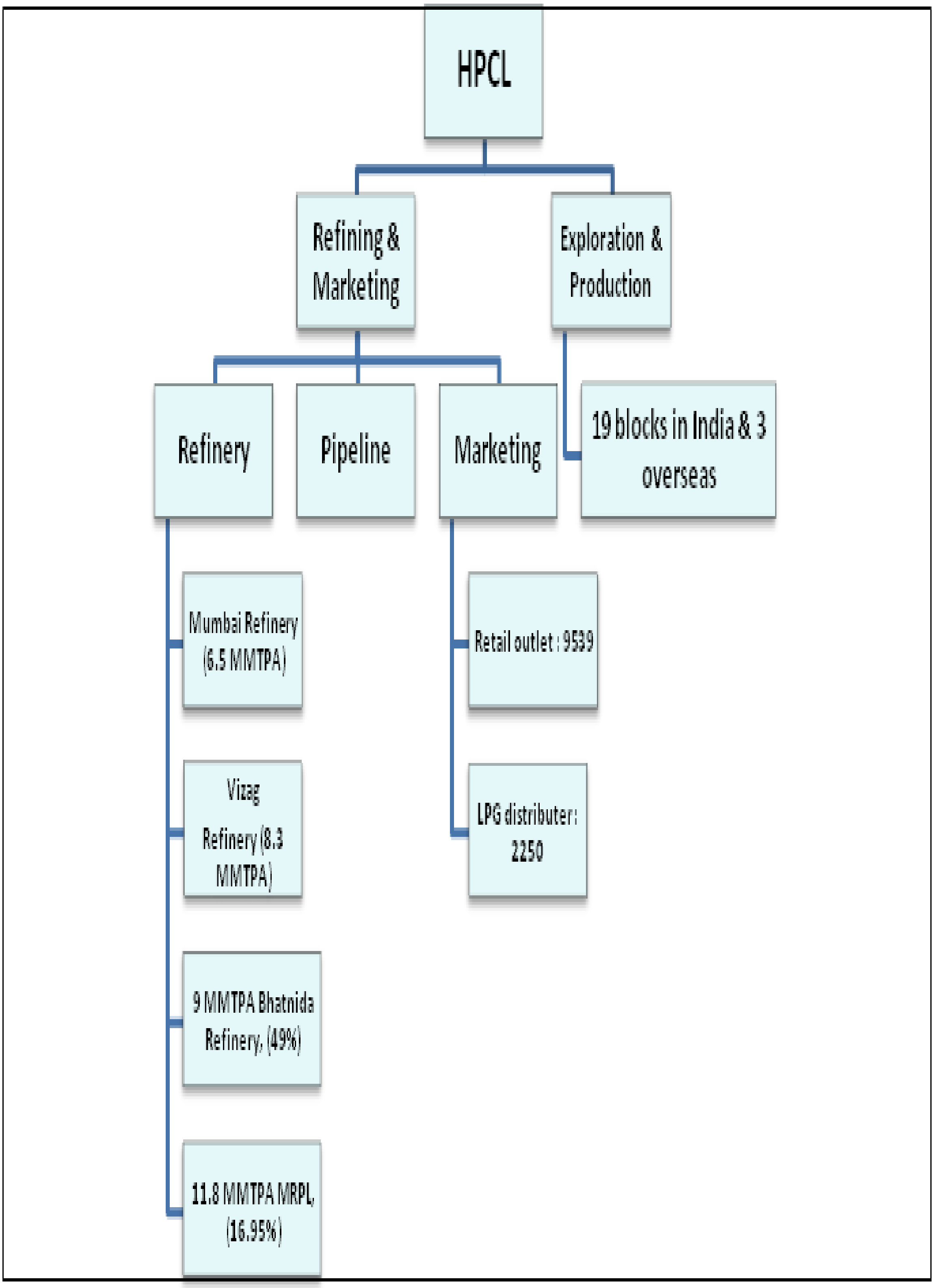
2.1 PROFILE

Name	:	Hindustan Petroleum Corporation Limited (HPCL)
Incorporation	:	1974
Constitution	:	Public Limited Company
Sector	:	Petroleum Refinery
Industry	:	Petroleum
Activities	:	Bitumen, LPG, CNG, and downstream petroleum products.

2.2 BACKGROUND OF COMPANY AND OPERATIONS

HPCL, a Government of India undertaking and a Fortune 500 company, is one of the major integrated oil refining and marketing companies in India. It is a Mega Public Sector Undertaking (PSU) with Navaratna status.

HPCL accounts for about 20% of the market share and about 10% of the nation's refining capacity with two coastal refineries, one at Mumbai (West Coast) having a capacity of 6.5 Million Metric Tonnes Per Annum (MMTPA) and the other in Vishakapatnam (East Coast) with a capacity of 8.3 MMTPA. HPCL also holds an equity stake of 16.95% in Mangalore Refinery & Petrochemicals Limited (MRPL), a state-of-the-art refinery at Mangalore with a capacity of 9 MMTPA. In addition, HPCL, in collaboration with M/s Mittal Energy Investment Pte.Ltd. has set up a 9 MMTPA refinery at Bathinda, in the state of Punjab, as a Joint Venture.


HPCL
Refining & Marketing
Exploration & Production
Refinery
Pipeline
Marketing
19 blocks in India & 3 overseas
Mumbai Refinery (6.5 MMTPA)
Vizag Refinery (8.3 MMTPA)
9 MMTPA Bhatnida Refinery, (49%)
11.8 MMTPA MRPL, (16.95%)
Retail outlet : 9539
LPG distributer: 2250

HPCL owns the country's largest Lube Refinery with a capacity of 335,000 Metric Tonnes which amounts to 40% of the national capacity of Lube Oil production. HPCL has given India a firm ground in this sector with its world class standard of Lube Base Oils. Presently HPCL produces over 300+ grades of Lubes, Specialities and Greases.

HPCL has earned "**Excellent**" performance for fifteen Consecutive years upto 2005-06, since signing of the first MOU with the Ministry of Petroleum & Natural Gas. **HPCL won the prestigious MOU Award for the year 2007-08 for Excellent Overall Performance, and for being one of the Top Ten Public Sector Enterprises who fall under the 'Excellent' category**. HPCL's performance for the year 2010-11 also qualifies for "Excellent" rating.

HPCL, over the years, has moved from strength to strength on all fronts. The refining thruput has increased three fold between 1984/85 to 2007/08, rising from 4.47 MMTPA in 1984/85 to 16.19 MMTPA (2011-12).

HPCL is the second largest player in Indian Oil sector and in highly competitive lubricants market. It was formed in 1974 on nationalization of ESSO India operations.

HPCL has two refineries producing a wide variety of petroleum products-one in Mumbai (West Coast) and the other in Visakhapatnam (East Coast). The HPCL refinery in Visakhapatnam is also known as " **VISAKH REFINERY** ".

2.3 TYPE OF INDUSTRY

HPCL refinery can be classified as an analytical type of industry. It is petrochemical industry i.e. broadly speaking chemical engineering industry.

Petroleum refinery is a production industry where raw material crude petroleum is transformed into various useful products using some chemical processes.

3. PRODUCTS

PRODUCTS

1. **Petrol** Known as Motor Spirit(MS) in Oil Industry. HPCL markets the product through its retail pumps spread all over India. Its principle consumers are regular personal vehicle owners.
2. **Diesel** Known as Heavy Stock Diesel(HSD) in Oil Industry. HPCL markets the products through its retail pumps as well as terminals and depots. Its consumers are not only regular auto owners but also transport agencies, industries etc.
3. **Lubricants** HPCL is the market leader in lubricant and associated products. It commands over 30% of market share in this sector. The popular brands of HP lubes are Laal Ghoda, Milcy, Thanda Raja, Koolgard etc.
4. **LPG** A popular brand in mainly urban areas.
5. **Aviation Turbine Fuel** [With major ASF(Air Service Facility) present in all major airports of India. HPCL is a key player in this sector supplying ATF to major airlines. It has an accomplishment of sorts to supply fuel to US Air Force 1.
6. **Bitumen & Furnace Oil**

4. REFINERIES & MAJOR FACILITIES

4.1 REFINERIES

HPCL has a number of refineries in India. Some are listed below:

1. Mumbai Refinery - 5.5 Million Metric Tonnes (MMT) Capacity
2. Visakhapatnam Refinery - 8.3 MMT at Visakhapatnam
3. Mangalore Refinery Pvt. Ltd. - 9.69 MMT at Mangalore, Karnataka(HPCL has 16.65% Stake).
4. Guru Gobind Singh Refinery - 9 MMT at Bhatinda, Punjab(HPCL & Mittal Energy each have 49% stake).

4.2 MAJOR FACILITIES

1. Mumbai refinery Fuel & Lubes
2. Vizag refinery Fuel.
3. Lube, Grease & Specialty State of art plant Silvassa. One of the most advanced fully automated Installation in ASIA.
4. Lube & Grease mfg facility, mazagaon Mumbai.
5. Mangalore Lube Refinery.
6. LPG storage Cavern one of the biggest storage facility of LPG in Asia at Vizag.
7. MRPL, PSPL, MDPL, VSPL.
8. Several Terminals & depots.
9. Many LPG botteling plants.

5. CAPACITY

Hindustan Petroleum Corporation Limited (HPCL) is a Global Fortune 500 company in the Energy sector. HPCL has two Refineries located in Mumbai (West Coast) and Visakh (East Coast) with capacities of **6.5 MMTPA** and **8.3 MMTPA** respectively, churning out a wide range of petroleum products, viz. LPG, MS, SKO, ATF, HSD, Bitumen etc. and various grades of lubricants, specialties and greases as per BIS standard. Initially t The installed capacity of 1.5 MMTPA was increased to 4.5 MMTPA in 1985 and 7.5 MMTPA in 1999, Over the years HPCL's capacity of production has expanded massively through various upgradation initiatives. The Refineries known for the full utilization of capacity and world class performance are the foundations of HPCL's successful journey towards meeting India's energy requirements.

Mumbai Refinery is a Lube based refinery with the highest lube production capacity in India. The offsite product handling facilities of Refineries at Mumbai and Visakhapatnam has been automated and facilities upgraded to produce green fuels like unleaded petrol and low sulphur diesel. HPCL is committed to upheld India's position in the global energy scenario as a useful contributor.

The Refineries are operated efficiently to comply with international quality standard. Both Refineries have been operated their capacity utilization above 100%. The consistent maintenance of standard has fetched the two refineries numerous awards. The Refineries can claim the lion's share of HPCL's contribution in the field of energy conservation, environment and safety. For HPCL, success is never an end in itself and hence the Refineries will go through further upgradation in future

6. LOCATION SELECTION CRITERIA

Oil Refineries process millions of gallons of oil that have been drilled from the Earth's crust. Choosing the location of an oil refinery is not an easy task because a number of environmental and safety concerns need to be taken into account.

India does not have high crude oil reserves, and hence it depends totally on import of petroleum crude oil. Gulf countries are the main suppliers to India.

Transportations and refining costs are very high for any refinery and hence these factors take priority in considering plant location.

Visakh Refinery (Visakhapatnam)

Oil Refineries are often located on the coast and away from busy cities. When choosing the location for an oil refinery, the following factors need to be taken into consideration:

6.1 COAST

HPCL is located at its Chembur in Mumbai and Vizag in Andhra Pradesh because of the proximity of sea routes from the plant location. As for transportation purpose, the raw material used in the production in HPCL i.e. crude oil can be easily transported via the sea routes.

6.2 AVAILABILITY OF RESOURCES

Available workforce: –

It may be tempting to build an oil refinery in a remote location where no people or animals can be affected. However, a refinery needs workers living relatively nearby. Even though HPCL refinery is far from residential area transport facilities from workers quarters is available.

Available customers: –

Oil refineries need to be within easy reach of customers. It is essential to have good transport links. Some refineries are pipelines as a method of transportation.

7. REFINERY OPERATIONS

The Refinery Operations are divided into different sections.

- Oil Transportation and Storage
- Production
- Power & Utilities

7.1 TRANSORTATION

The oil refinery must be near to rail, road or sea links and close to the site the oil has been drilled. HPCL has port near to it.

Modes Of Transport : -

The Oil to HPCL Visakh Refinery is transported in different ways. They are :

- **Sea Ways**
- **Rail Ways**
- **Road Ways**
- **Pipelines**

7.2 OIL STORAGE

The commissioning of South Asia's first of its kind 60,000 MT capacity Liquefied Petroleum Gas (LPG) underground cavern storage facility in Visakhapatnam, Andhra Pradesh has commenced on 26 December 2007 with in-take from 40000 MT capacity VLGC (Very Large Gas Carrier) "Maharshi Bharadwaj" of Varun Shipping.

The Cargo of 39200 MT LPG was arranged by Hindustan Petroleum Corporation Limited (HPCL) for the PSU Oil Marketing Companies from Saudi Arabia. This is the first time such a very large vessel has entered the country with full LPG cargo.

The Cavern, an engineering marvel and first of its kind in South and South-East Asia, is set up by the South Asia LPG Company Limited (SALPG), which is a 50:50 joint venture between the Hindustan Petroleum Corporation Limited (HPCL) and TOTAL, a French Oil major. The Rs. 333-crore project has come up at Lova Garden near Dolphin's nose hill in Visakhapatnam, Andhra Pradesh. The foundation for the project was laid on February 19, 2004

The Cavern has been dug in solid hard rock to store LPG at 162 M below mean sea level (MSL). The deepest portion of the cavern is 196 M below MSL. The storage facility is made up of two caverns of 19 M height, 20 M base width and 160 M in length with interconnections. The cavern is designed on "water containment principle" and is jacketed with water curtain. Besides being safe from natural calamities and hazards like sabotage, and aerial bombings, the caverns are leak and fireproof.

The Cavern is expected to ease the storage constraints on the eastern coast and will enable the Oil Industry meet the ever growing demand of LPG in the country. The large ocean cargoes are expected to bring-in freight economics. Further, the large parcels with higher tanker discharge rates will reduce the berth occupancy by LPG Vessels at Visakhapatnam Port.

8. PRIMARY PROCESSING UNITS

Primary process units consists of three Crude Distillation Units, namely CDU-1, CDU-2 & CDU-3.

8.1 CRUDE DISTILLATION UNITS

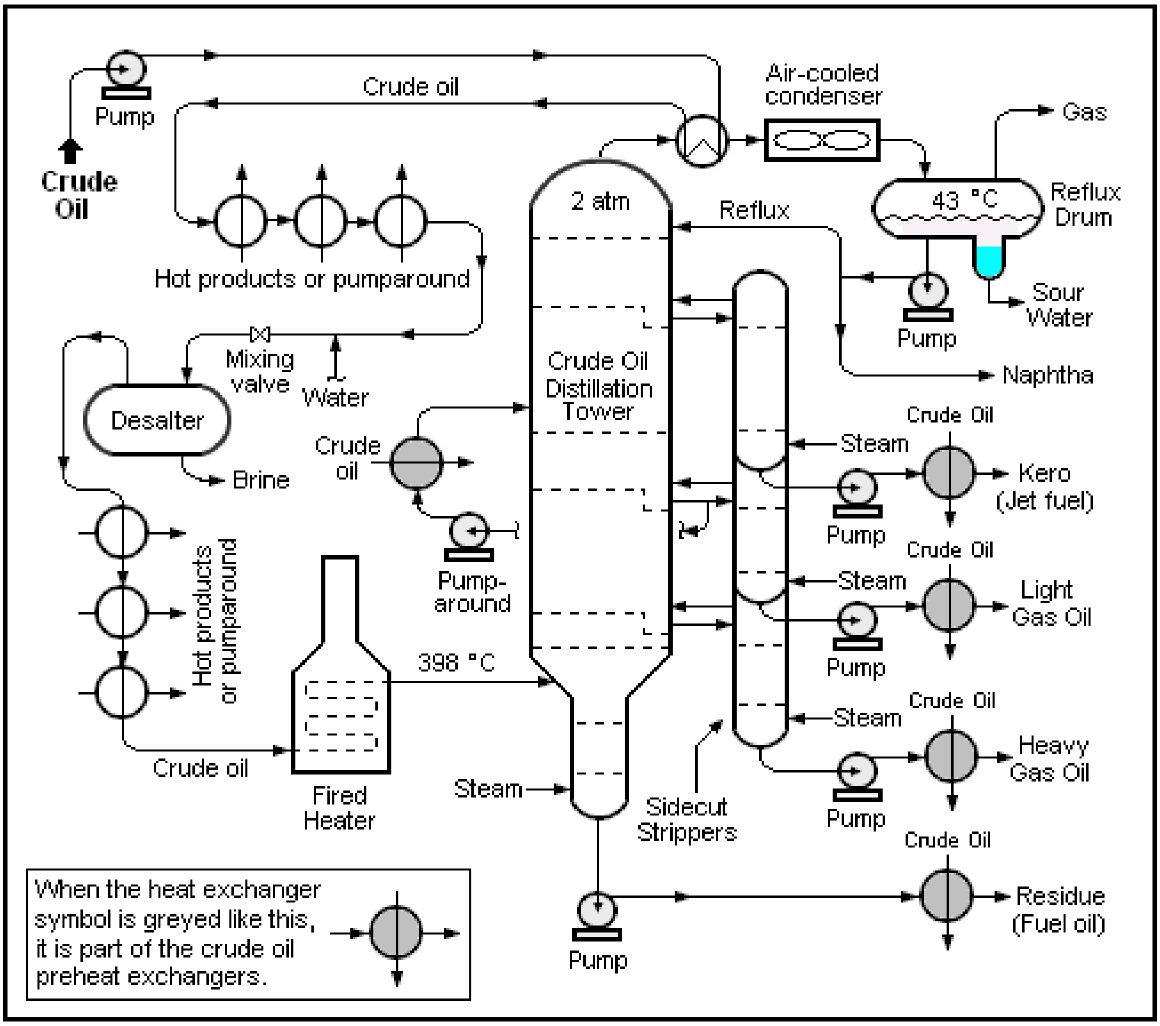
Major Equipment:

Desalter, Atmospheric Furnace, Atmospheric column, Vaccum Furnace, Vaccum Column, Preheat Exchangers/ Coolers.

The crude oil distillation unit (CDU) is the first processing unit in virtually all petroleum refineries. The CDU distills the incoming crude oil into various fractions of different boiling ranges, each of which are then processed further in the other refinery processing units. The CDU is often referred to as the *atmospheric distillation unit* because it operates at slightly above atmospheric pressure.

Below is a schematic flow diagram of a typical crude oil distillation unit. The incoming crude oil is preheated by exchanging heat with some of the hot, distilled fractions and other streams. It is then desalted to remove inorganic salts (primarily sodium chloride).

Following the desalter, the crude oil is further heated by exchanging heat with some of the hot, distilled fractions and other streams. It is then heated in a fuel-fired furnace (fired heater) to a temperature of about 398 °C and routed into the bottom of the distillation unit.The cooling and condensing of the distillation tower overhead is provided partially by exchanging heat with the incoming crude oil and partially by either an air-cooled or water-cooled condenser. Additional heat is removed from the distillation column by a pumparound system as shown in the diagram below.



As shown in the flow diagram, the overhead distillate fraction from the distillation column is naphtha. The fractions removed from the side of the distillation column at various points between the column top and bottom are called *sidecuts*. Each of the sidecuts (i.e., the kerosene, light gas oil and heavy gas oil) is cooled by exchanging heat with the incoming crude oil. All of the fractions (i.e., the overhead naphtha, the sidecuts and the bottom residue) are sent to intermediate storage tanks before being processed further.

8.2 DISTILLATION

Distillation is the first step in the processing of crude oil and it takes place in a tall steel tower called a fractionation column. The inside of the column is divided at intervals by horizontal trays. The column is kept very hot at the bottom (the column is insulated) but as different hydrocarbons boil at different temperatures, the temperature gradually reduces towards the top, so that each tray is a little cooler than the one below. The crude needs to be heated up before entering the fractionation column and this is done at first in a series of heat exchangers where heat is taken from other process streams which require cooling before being sent to rundown. Heat is also exchanged against condensing streams from the main column. Typically, the crude will be heated up in this way upto a temperature of 200 - 280 °C, before entering a furnace.

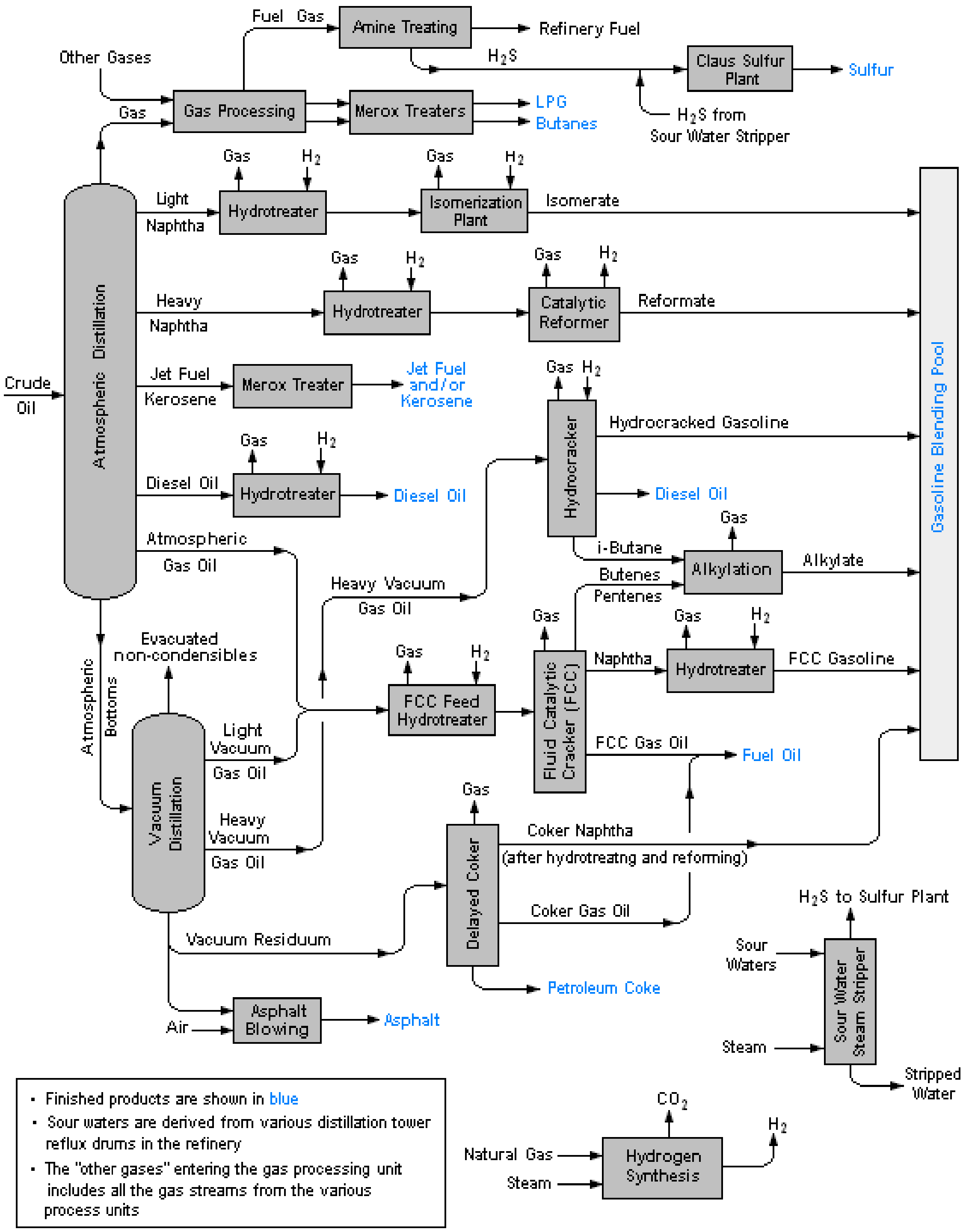
As the raw crude oil arriving contains quite a bit of water and salt, it is normally sent for salt removing first, in a piece of equipment called a desalter. Upstream the desalter, the crude is mixed with a water stream, typically about 4 - 6% on feed. Intense mixing takes place over a mixing valve and (optionally) as static mixer. The desalter, a large liquid full vessel, uses an electric field to separate the crude from the water droplets. It operates best at 120 - 150 °C, hence it is conveniently placed somewhere in the middle of the preheat train. Part of the salts contained in the crude oil, particularly magnesium chloride, are hydrolysable at temperatures above 120 °C.

Upon hydrolysis, the chlorides get converted into hydrochloric acid, which will find its way to the distillation column's overhead where it will corrode the overhead condensers. A good performing desalter can remove about 90% of the salt in raw crude.

9. FLOW DIAGRAM OF A TYPICAL REFINERY

Desalter, crude is further heated up with heat exchangers, and starts vaporising, which will increase the system pressure drop. At about 170 -200 ^{o}C, the crude will enter a 'pre-flashvessel', operating at about 2 - 5 barg, where the vapours are separated from the remaining liquid. Vapours are directly sent to the fractionation column, and by doing so, the hydraulic load on the remainder of the crude preheat train and furnace is reduced (smaller piping and pumps). Just upstream the preflash vessel, a small caustic stream is mixed with the crude, in order to neutralise any hydrochloric acid formed by hydrolysis.

The sodium chloride formed will leave the fractionation column via the bottom residue stream. The dosing rate of caustic is adjusted based on chloride measurements in the overhead vessel (typically 10 - 20 ppm). At about 200 - 280 ^{o}C the crude enters the furnace where it is heated up further to about 330 -370 ^{o}C. The furnace outlet stream is sent directly to the fractionation column. Here, it is separated into a number of fractions, each having a particular boiling range. At 350 ^{o}C, and about 1 barg, most of the fractions in the crude oil vapourise and rise up the column through perforations in the trays, losing heat as they rise. When each fraction reaches the tray where the temperature is just below its own boiling point, it condenses and changes back into liquid phase. A continuous liquid phase is flowing by gravity through 'downcomers' from tray to tray downwards. In this way, the different fractions are gradually separated from each other on the trays of the fractionation column. The heaviest fractions condense on the lower trays and the lighter fractions condense on the trays higher up in the column. At different elevations in the column, with special trays called draw-off trays, fractions can be drawn out on gravity through pipes, for further processing in the refinery. At top of the column, vapours leave through a pipe and are routed to an overhead condenser, typically cooled by air fin-fans. At the outlet of the overhead condensers, at temperature about 40 ^{o}C, a mixture of gas, and liquid naphtha exists, which is falling into an overhead accumulator.



Fuel Gas
Amine Treating
Refinery Fuel
Other Gases
H_2S
Claus Sulfur Plant
Sulfur
Gas
Gas Processing
Merox Treaters
LPG
Butanes
H_2S from Sour Water Stripper
Gas
H_2
Gas
H_2
Light Naphtha
Hydrotreater
Isomerization Plant
Isomerate
Gas
H_2
Gas
H_2
Heavy Naphtha
Hydrotreater
Catalytic Reformer
Reformate
Atmospheric Distillation
Crude Oil
Jet Fuel Kerosene
Merox Treater
Jet Fuel and/or Kerosene
Gas H_2
Hydrocracker
Hydrocracked Gasoline
Gasoline Blending Pool
Gas
H_2
Diesel Oil
Hydrotreater
Diesel Oil
Diesel Oil
Gas
Atmospheric Gas Oil
i-Butane
Alkylation
Alkylate
Heavy Vacuum Gas Oil
Butenes
Pentenes
Gas
Gas
H_2
Evacuated non-condensibles
Gas
H_2
Naphtha
Hydrotreater
FCC Gasoline
Atmospheric Bottoms
FCC Feed Hydrotreater
Fluid Catalytic Cracker (FCC)
Light Vacuum Gas Oil
FCC Gas Oil
Fuel Oil
Vacuum Distillation
Gas
Heavy Vacuum Gas Oil
Coker Naphtha
(after hydrotreatng and reforming)
Delayed Coker
H_2S to Sulfur Plant
Coker Gas Oil
Vacuum Residuum
Sour Waters
Petroleum Coke
Sour Water Steam Stripper
Asphalt Blowing
Asphalt
Air
Steam
Stripped Water
• Finished products are shown in blue
• Sour waters are derived from various distillation tower reflux drums in the refinery
• The "other gases" entering the gas processing unit includes all the gas streams from the various process units
CO_2
H_2
Natural Gas
Hydrogen Synthesis
Steam

Gases are routed to a compressor for further recovery of LPG (C3/C4), while the liquids (gasoline) are pumped to a hydrotreater unit for sulfur removal. A fractionation column needs a flow of condensing liquid downwards in order to provide a driving force for separation between light and heavy fractions. At the top of the column this liquid flow is provided by pumping a stream back from the overhead accumulator into the column. Unfortunately, a lot of the heat provided by the furnace to vaporise hydrocarbons is lost against ambient air in the overhead fin-fan coolers. A clever way of preventing this heat lost of condensing hydrocarbons is done via the circulating refluxes of the column.

In a circulating reflux, a hot side draw-off from the column is pumped through a series of heat exchangers (against crude for instance), where the stream is cooled down. The cool stream is sent back into the column at a higher elevation, where it is been brought in contact with hotter rising vapours. This provides an internal condensing mechanism inside the column, in a similar way as the top reflux does which is sent back from the overhead accumulator.

The main objective of a circulating reflux therefore is to recover heat from condensing vapours. A fractionating column will have several (typically three) of such refluxes, each providing sufficient liquid flow down the corresponding section of the column. An additional advantage of having circulating refluxes is that it will reduce the vapour load when going upwards in the column. This provided the opportunity to have a smaller column diameter for top sections of the tower. Such a reduction in diameter is called a 'swage'.

The lightest side draw-off from the fractionating column is a fraction called kerosene, boiling in the range 160 - 280 ^{o}C, which falls down through a pipe into a smaller column called 'side-stripper'. The purpose of the side stripper is to remove very light hydrocarbons by using steam injection or an external heater called 'reboiler'. The stripping steam rate, or reboiled duty is controlled such as to meet the flashpoint specification of the product. Similarly to the atmospheric column, the side stripper has fractionating trays for providing contact between vapour and liquid.

The vapours produced from the top of the side stripper are routed back via pipe into the fractionating column. The second and third (optional) side draw-offs from the main fractionating column are gasoil fractions, boiling in the range 200 - 400 ^{o}C, which are ultimately used for blending the final diesel product. Similar as with the kerosene product, the gasoil fractions (light and heavy gasoil) are first sent to a side stripper before being routed to further treating units.

At the bottom of the fractionation column a heavy, brown/black coloured fraction called residue is drawn off. In order to strip all light hydrocarbons from this fraction properly, the bottom section of the column is equipped with a set of stripping trays, which are operated by injecting some stripping steam (1 - 3% on bottom product) into the bottom of the column.

10. TRAY TYPES & SUMMARIZING CDU'S

Tray types:

- Trays with down comers (bubble cap, sieve, valve)
- Trays without down comers (qual flow, baffle)
- Multi down comer trays – collection of chimney trays.

Number of equilibrium stages = number of trays.

Tray spacing ≈ 300 – 900 mm (basis of adequate insurance against flooding and entrainment on cost and maintenance.

Packed Columns are preferred to tray towers under

- For columns of less than 2 ft diameter.
- For acids and other corrosive materials.
- For foaming liquids.
- For thermally sensitive liquids (requires low liquid hold-up).
- For lower pressure drop or vacuum operations.
- For greater mass transfer efficiencies.

Summarizing CDU's:

CDU – ADU's (Atmospheric Distillation Unit), VDU's (Vacuum Distillation Unit)

- Generally used for design capacity < 90%.
- For > 90% --
    - High product rundown temperature.
    - Stabilize reboilers duty
    - low preheat and consequent overloading of atmospheric column.

11. FLUID CATALYST CRACKING UNIT

Major Equipment:

Regenerator, Reactor, Main Fractionator, Primary Absorber, Sponge Absorber, Main Air Blower, Wet Gas Compressor, De butaniser, Stripper.

Description:

Fluid catalytic cracking (FCC) is one of the most important conversion processes used in petroleum refineries. It is widely used to convert the high-boiling, high-molecular weight hydrocarbon fractions of petroleum crude oils to more valuable gasoline, olefinic gases, and other products.[1][2][3] Cracking of petroleum hydrocarbons was originally done by thermal cracking, which has been almost completely replaced by catalytic cracking because it produces more gasoline with a higher octane rating. It also produces byproduct gases that are more olefinic, and hence more valuable, than those produced by thermal cracking.

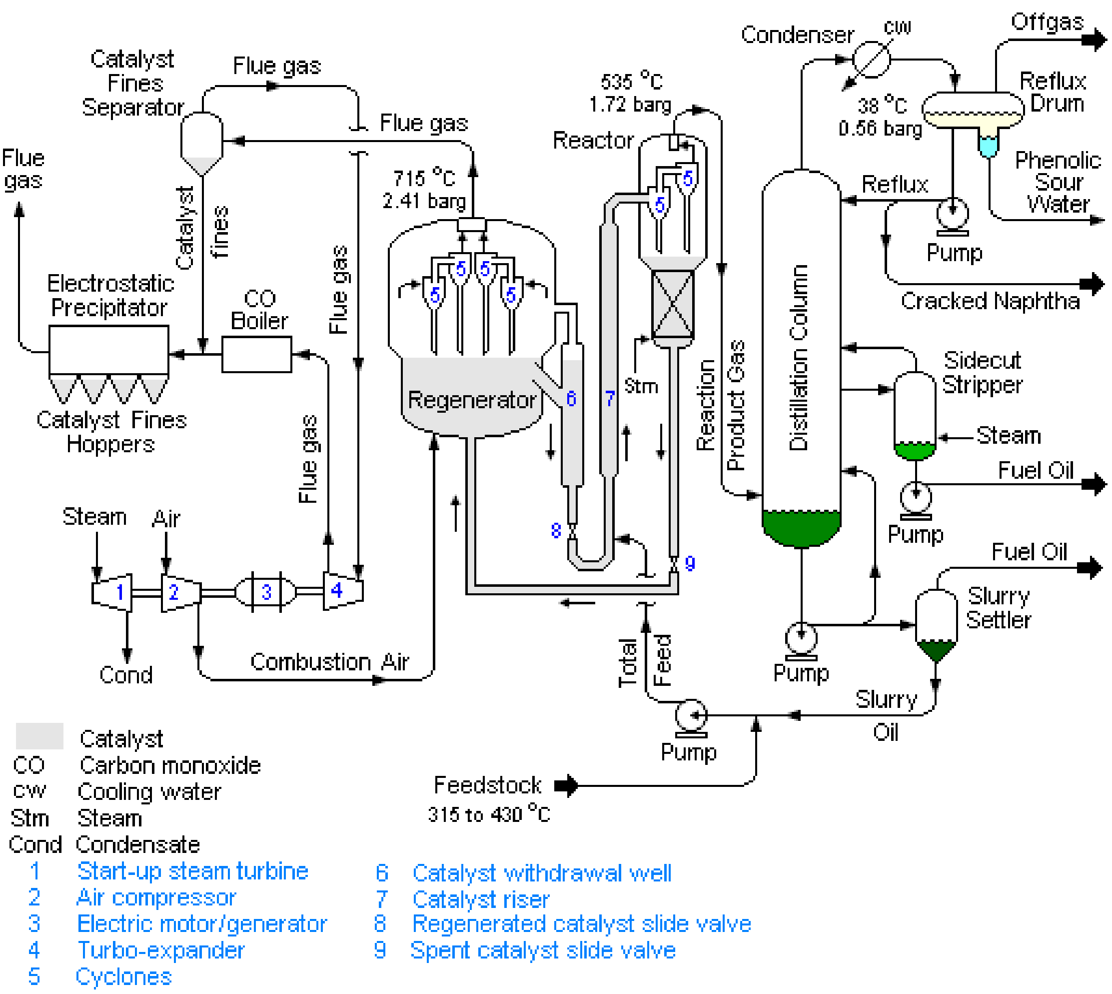
The feedstock to an FCC is usually that portion of the crude oil that has an initial boiling point of 340 °C or higher at atmospheric pressure and an average molecular weight ranging from about 200 to 600 or higher. This portion of crude oil is often referred to as heavy gas oil or vacuum gas oil (HVGO). The FCC process vaporizes and breaks the long-chain molecules of the high-boiling hydrocarbon liquids into much shorter molecules by contacting the feedstock, at high temperature and moderate pressure, with a fluidized powdered catalyst.

In effect, refineries use fluid catalytic cracking to correct the imbalance between the market demand for gasoline and the excess of heavy, high boiling range products resulting from the distillation of crude oil.

Flow Diagram and Process Description:

The modern FCC units are all continuous processes which operate 24 hours a day for as long as 2 to 3 years between scheduled shutdowns for routine maintenance.

There are several different proprietary designs that have been developed for modern FCC units. Each design is available under a license that must be purchased from the design developer by any petroleum refining company desiring to construct and operate an FCC of a given design.



There are two different configurations for an FCC unit: the "stacked" type where the reactor and the catalyst regenerator are contained in a single vessel with the reactor above the catalyst regenerator and the "side-by-side" type where the reactor and catalyst regenerator are in two separate vessels. These are the major FCC designers and licensor.

Reactor and Regenerator:

The reactor and regenerator are considered to be the heart of the fluid catalytic cracking unit. The reactor is a vessel in which the cracked product vapors are: (a) separated from the so-called *spent catalyst* by flowing through a set of two-stage cyclones within the reactor and (b) the *spent catalyst* flows downward through a steam stripping section to remove any hydrocarbon vapors before the spent catalyst returns to the *catalyst regenerator*.

The flow of spent catalyst to the regenerator is regulated by a *slide valve* in the spent catalyst line.

The reactor is a vessel in which the cracked product vapors are: (a) separated from the so-called *spent catalyst* by flowing through a set of two-stage cyclones within the reactor and (b) the *spent catalyst* flows downward through a steam stripping section to remove any hydrocarbon vapors before the spent catalyst returns to the *catalyst regenerator*.

The flow of spent catalyst to the regenerator is regulated by a *slide valve* in the spent catalyst line.

12. VIS BREAKING UNIT

Objective:

To achieve viscosity reduction and obtain lighter products by thermal cracking of VR / SR. It reduces cutter consumption.

Feed:

VR from CDU's.

Products :

VBLPG, VB Naphtha, VB Gas Oil, VB tar

Capacity:

1 MMTPA

Major Equipment:

Furnace, soaker, fractionator, stabilizer, absorber.

Process :

Vacuum Residue from Vacuum Column after preheating is preheated to desired temperature in fired heater furnace. Steams coming out of furnace are routed to Soaker drum for completing the Vis-Breaking reaction. The Soaker effluent streams are routed to fractionator column after quenching by Gas Oil generation LPG, Naphtha, Gas Oil, Vis Tar.

Monitoring:

Conversion, viscosity reduction ratio, heater, soaker, fractionator performance development of improvement scheme.

13. BITUMEN BLOWING UNIT

Objective:

To produce different grades of bitumen.

Feed:

SR (short residue)

Major Equipment:

Reactor, Heat Exchangers, Compressor.

Capacity:

0.225 MMTPA

Process :

The hot vacuum bottoms is cooled to about 230C in a steam generator before entering the Bitumen convertor where it is blown with air. The reaction is exothermic and the heat evolved is removed by injecting steam into the reactor at the top. Heat is recovered from Bitumen before sending it to the storage. Different grades of Bitumen are obtained by improving the penetration.

Product :

Bitumen of different grades (Pero:60-70, 80-100)

14. TREATING UNITS

There are 6 types of Treating Units :

1. Diesel Hydro Desulphurization Unit
2. Hydrogen Generation Unit
3. Sulphur Recovery unit
4. MEROX (LPG, CRN, ATF)
5. LPG Amine Treating unit
6. Propylene Recovery unit.

14.1 DIESEL HYDRO DESULPHURIZATION UNIT

Objective:

Desulphurise diesel to meet BS-II / Euro-3 standard

Major Equipment:

Reactor, Heater, MGC, RGC, Feed filter, Stripper, Stablizer, Heat Exchanger, Hot Separator, Cold Separator, Coalescer.

Process :

The Sulphur compounds present in diesel is removed in the presence of hydrogen and catalyst in the reactor maintained at desire temperature and high pressure. Hydrogen sulphide generated in the process is removed after amine treating in Sulphur recovery unit.

14.2 HYDROGEN GENERATION UNIT

Capacity:

25000 Nm^3/hr

1. Naphtha sweetning (PDS & FDS)
2. Naphtha Cracking (Reforming)
3. Hydrogen purification & recovery

Major Equipment:

Stripper, Reactor (Desulphurisation), Heater, Vaporiser, Reactor (H_2S Adsorption), Reformer, Steam Drum, Degassifier, Pressure Swing Absorption vessels, Purge vessel .

Process :

Hydrogen requird for the DHDS process is generated in Hydrogen Plant using Naphtha as feed and fuel for burning. The steam reforming reaction of Naphtha is high temperature reaction.

14.3 SULPHUR RECOVERY UNIT

Process :

Hydrogen Sulphide rich gas DHDS is routed to SRU for recovery of Sulphur and reducing the H_2S content in the fuel gas.

14.4 LPG MEROX

Objective:

Treating LPG / ATF either by removal of Sulphur or changing the Sulphur form.

Feed:

LPG from CDU, FCCUs and VBU.

ATP from CDUs.

Major Equipment:

Extractor, Caustic Pre-wash, Disulphide, Separator, Oxidiser, Sand Filter, Caustic Settler.

Process :

Traces of Hydrogen Sulphide and Mercaptans present in Straight and cracked LPG are removed by oxidizing them into odourless disulphides.

14.5 CRN MEROX

Major Equipment:

Reactors, Caustic Settler. Sand Filters.

Process :

Cracked Naphtha mixture from Fluid Catalytic Cracking Units mixed with air and routed to a reactor where Merox catalyst impregnated on charcoal bed removes the foul smelling Mercaptans by converting them to odourless disulphides.

14.6 ATF MEROX

Major Equipment:

Coalescer, Reactor, Water Washer, Caustic Settler.

Process :

Kerosene along with air is routed to the Merox reactor where Mercaptans are converted to disulphides. Entrained caustic is separated out in Caustic Settler and traces of moisture and other extraneous matter are removed in salt and clay filters. This unit helps in manufacture of ATF.

Product :

LPG/ATF reactor product specification.

Monitoring :

Product quality, Caustic regeneration

14.7 LPG AMINE TREATING UNIT

Major Equipment:

Absorber, Extractor, Sand Filter, Settlers, heater, oxidiser.

Process :

Hydrogen Sulphide present in the Straight Run LPG & Cracked Run LPG is removed by using Di Ethanol Amine.

14.8 PROPYLENE RECOVERY UNIT

Objective:

To recover Propylene from treated CRLPG.

Major Equipment:

Caustic Settler, Sand filter, Feed Surge Drum, C3-C4 Splitter, C3-C3' Splitter, Wash Water Vessel.

Feed:

CRLPG.

Process :

Propylene is recovered from the mixture of C3-C3' gases.

Salient Features :

Very low relative volatility between components.

15. VRCFP UNITS & FCC NHT

For Euro-3 and Euro-4 Grade MS product

- Naphtha Hydrotreater (NHT)
- Continuous Catalytic reformer (CCR)
- FCC CRN Hydrotreater (FCC-NHT)
- Isomerization unit (ISOM)

FCC NHT (Prime G+) :

Major Equipment :

Feed surge drum, Selective Hydrogenation Unit Reactor, Splitter column, HDS Reactor, Stabilizer, Amine Absorber etc.

Objective:

The objective of FCC Naphtha Hydro treating Unit is to process FCC Gasoline to obtain product streams (Light gasoline and Heavy Hydrogenated gasoline) with targeted qualities of octane number, benzene content and olefins content.

Prime G+ provides us with "Handles" to meet EURO-3/EURO-4 Specifications of Gasoline wrt:

Diolefins	: nil
Olefins	: 18% Max.
Sulphur	: 50 ppm
Benzene	: 1%

This can be achieved in the unit with maximum penalty on Octane.

Process :

FCC CRN from FCCU is taken to the unit as hot feed. The CRN is taken to a feed surge drum. CRN is then pumped through a series of Heat exchangers and enters into the Selective Hydrogenation Unit Reactor. The purpose of the Reactor is to convert the diolefins to olefins and to convert the mercaptans and lighter boiling sulphur compounds in the feed higher boiling sulphur species.

The outlet from SHU Reactor is routed to splitter where Light Naphtha Heart cut naphtha and Heavy naphtha are separated. Light naphtha is directly routed to MS pool where a Heart cut naphtha which is rich in benzene content is routed to NHT unit.

The bottom heavy naphtha is passed again through series of heat exchangers and routed to Hydrodesulphurizaton Reactor (HDS Reactor). Here the sulphur of the heavy naphtha is reduced to allowable extent and the desulphurized heavy gasoline (HSN) from the HDS reactor is routed to Naphtha stabiliser. The HCN is is stripped off any dissolved H_2S or lighter compounds like C1, C2 and the stable HCN is routed to final Refinery MS pool.

16. NHT

NHT :

Major Equipment :

HDS reactor, stripper, charge heater, charge heater, splitter and splitter reboiler.

Process :

The Sulphur present in Straight run naphtha is removed in the presence of Hydrogen and the Catalyst in the reactor maintained at desired temperature and high pressure. Hydrogen sulphide generated in the process is removed by stripping. Sweet naphtha splits into Light naphtha (feed to Isom unit) and Heavy naphtha (feed to CCR) in splitter.

17. NAPHTHA ISOMERIZATION UNIT (NIU) :

Major Equipment :

Hydrogenation Reactor, Isomerization Reactors, Flash Drum, Stabilizer column, De-Isohexaniser column, Hydrogen dryers, Naphtha dryers, LPG separator drum, scrubber column, H2 gas compressor.

Objective:

The objective of Isom Unit is to process Light naphtha from NHT to obtain high octane number gasoline.

Process :

Benzene content in light naphtha will be reduced to cyclo hexane in the hydrogenation reactor and n-paraffinic HC present in Light naphtha get converted into iso paraffins by isomerization reactions. LPG and fuel gas are by products in this process. Light isomerate and heavy isomerate are the products from the unit which are routed to gasoline pool of Refinery.

18. CHEMICAL INJECTION FACILITIES

Demulsifier:

It is used for breaking the crude oil water emulsion in the desalter. Demulsifier is injected into the suction header of the crude charge pump.

Caustic:

It is required for maintaining the P^H of the desalter brine solution and for neutralizing the acid formed from residual salts remaining in the downstream of the desalter. Caustic is injected into the crude in the suction header and also in the downstream of desalter through a vortex mixer.

Ammonia:

It is injected into the crude column top to neutralize any HCL formed and to maintain the P^H of sour water of reflux drum.

Corrosion inhibitor:

It is injected on the reflux line and crude tower overhead lines to protect the line by forming a film on the wall of the tubes.

19. UTILITIES

DM Plants:

Objective:

To De-mineralize water which is used for steam generation.

Feed and Product:

Raw water is processed in Ion Exchangers to get Demineralized water. The latest technology used (in VRCFP) for DM water is Reverse Osmosis.

Monitoring:

Regeneration Audit.

Water Conservation

DM water Quality

Media filled vessel checking.

Power Plants:

Objective:

To generate steam for processes use.

CPP :

Objective:

To generate power for gas turbines.

Feed:

Naphtha is used to run a Gas Turbine generator and thus produce power which is used by whole refinery.

20. MAJOR ONGOING PROJECTS

In order to strengthen core processes and modernize, HPCL has developed ambitious plans for expansion and diversification in the areas of increasing energy demand, technological upgradation and environment management. HPCL has proposed capital expenditure (including equity investments in Joint Ventures) of Rs. 11487 Crores during the eleventh plan. A brief on some major projects in progress in different parts of India are given below:

- Rewari Kanpur Pipe Line (RKPL)
- Diesel Hydro Treating (DHT) at Mumbai & Visakhapatnam refineries

20.1 REWARI KANPUR PIPELINE (RKPL) :

Petroleum and Natural Gas Regulatory Board (PNGRB) has authorized HPCL to lay dedicated Petroleum Product Pipeline from Rewari (Haryana) to Kanpur (Uttar Pradesh). This pipeline will pass through the States of Haryana, Rajasthan and Uttar Pradesh. The length of this 18" Dia pipeline is approx. 441Km at an estimated Project cost of Rs. 1210 Crores. The Design capacity of the proposed pipeline is 7.98 MMTPA.

This pipeline envisages Tankage Facilities for the storage at

- Bharatpur (Rajasthan)
- Mathura (Uttar Pradesh)
- Palanpur (Gujarat)

The **Environmental Clearance** from The Ministry of Environment and Forests (MOEF) has been obtained

20.2 DIESEL HYDRO TREATING (DHT) AT MUMBAI & VISAKHAPATNAM REFINERIES :

HPCL is setting up Diesel Hydrotreater Units of 2.2 MMTPA each with associated facilities at Mumbai Refinery (MR) and Visakhapatnam Refinery (VR) to meet Euro-IV specifications for diesel as per the latest Auto Fuel Policy.

The **Environmental clearance** for the DHT projects for **Mumbai Refinery** and **Visakh Refinery** have been obtained.

The **Environmental Statement** of Visakh Refinery for the FY 2011-12 has been submitted to Andhra Pradesh Pollution Control Board (APPCB). View the **Compliance Status of Environmental Clearance** Stipulations for DHT VR Project.

The Revised cost of the project is estimated at INR 2174 Crores for Mumbai Refinery and INR 2730 Crores for Visakhapatnam Refinery. The projects are expected to be completed by September 2012.

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THANK

YOU !!