Distillation process of Crude oil

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Distillation process of Crude oil

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Crude oil is a fossil fuel, it was made naturally from decaying plants and animals living in ancient seas millions of years ago - most places you can find crude oil were once sea beds. Crude oils vary in color, from clear to tar-black, and in viscosity, from water to almost solid. The distillation process of Crude oil is the main concern of this paper. Here, we reported the ideas of different processes of distillations and their steps.

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Introduction:

Crude oil is the term for "unprocessed" oil, the materials that comes out of the ground. It is also known as petroleum. Crude oil is a fossil fuel, it was made naturally from decaying plants and animals living in ancient seas millions of years ago - most places you can find crude oil were once sea beds. Crude oils vary in color, from clear to tar-black, and in viscosity, from water to almost solid.

Crude oils are such a useful starting point for so many different substances because they contain hydrocarbons. Hydrocarbons are molecules that contain hydrogen and carbon and come in various lengths and structures, from straight chains to branching chains to rings.

Crude oil is processed or refined to produce useable products such as gasoline. The process is very complex and involves both chemical reactions and physical separations. Crude oil is composed of thousands of different molecules. It would be nearly impossible to isolate every molecule and make finished products from each molecule. Chemists and engineers deal with this problem by isolating mixtures of molecules according to the mixture's boiling point range.

The problem with crude oil is that it contains hundreds of different types of hydrocarbons all mixed together. To have anything useful it needs to separate the different types of hydrocarbons. Fortunately there is an easy way to separate things, and this is what oil refining is all about.

Crude Oil refinery process:

The oil refining process starts with a fractional distillation column. The various components of crude oil have different sizes, weights and boiling temperatures; so, the first step is to separate these components. Because they have different boiling temperatures, they can be separated easily by a process called fractional distillation. After going through the fractional distillation, crude oil is chemically processed to change one fraction into another. Finally, Distillated and chemically processed fractions are treated to remove impurities.

Fractional distillation:

This process is based on the principle that different substances boil at different temperatures. For example, crude oil contains kerosene and naphtha, which are useful fractions (naphtha is made into petrol for cars, and kerosene is made into jet fuel). When you evaporate the mixture of kerosene and naphtha, and then cool it, the kerosene condenses at a higher temperature than the naphtha. As the mixture cools, the kerosene condenses first, and the naphtha condenses later.

The major components of crude oil according to its specific temperature are as follows:

Name of the Component	State of matter	Number of carbons	Boiling range	Uses
Residuals	Solid	Multiple-ringed compounds with 70 or more carbon atoms	Greater than 600 degree Celsius	coke, asphalt, tar, waxes; starting material for making other products
Fuel oil	Liquid	Long chain; 20 to 70 carbon atoms	370 to 600 degree Celsius	used for industrial fuel; starting material for making other products
Lubricating oil	Liquid	Long chain; 20 to 50 carbon atoms	300 to 370 degree Celsius	used for motor oil, grease, other lubricants
Diesel distillate	Liquid	Alkanes containing 12 or more carbons	250 to 350 degree Celsius	used for diesel fuel and heating oil; starting material for making other products
Kerosene	Liquid	Mix of alkanes (10 to 18 carbons) and aromatics	175 to 325 degree Celsius	fuel for jet engines and tractors; starting material for making other products
Gasoline	Liquid	Mix of alkanes and cycloalkanes (5 to 12 carbon atoms)	40 to 205 degree Celsius	Motor fuel
Naphtha	Gas	mix of 5 to 9 carbon atom alkanes	60 to 100 degree Celsius	intermediate that will be further processed to make gasoline
Petroleum gas	Gas	Small alkanes (1 to 4 carbon atoms); commonly known by the names methane, ethane, propane, butane	40 degree Celsius	used for heating, cooking, making plastics

The fractional distillation of crude oil carries out several steps:

1. Heating the mixture of the substances of crude oil (liquids) with different boiling points to a high temperature. Heating is usually done with high pressure steam to temperatures of about 1112 degrees Fahrenheit / 600 degrees Celsius.

2. The mixture boils, forming vapor (gases); most substances go into the vapor phase.

3. The vapor enters the bottom of a long column (fractional distillation column) that is filled with trays or plates. The trays have many holes or bubble caps (like a loosened cap on a soda bottle) in them to allow the vapor to pass through. They increase the contact time between the vapor and the liquids in the column and help to collect liquids that form at various heights in the column. There is a temperature difference across the column (hot at the bottom, cool at the top).

4. The vapor rises in the column.

5. As the vapor rises through the trays in the column, it cools.

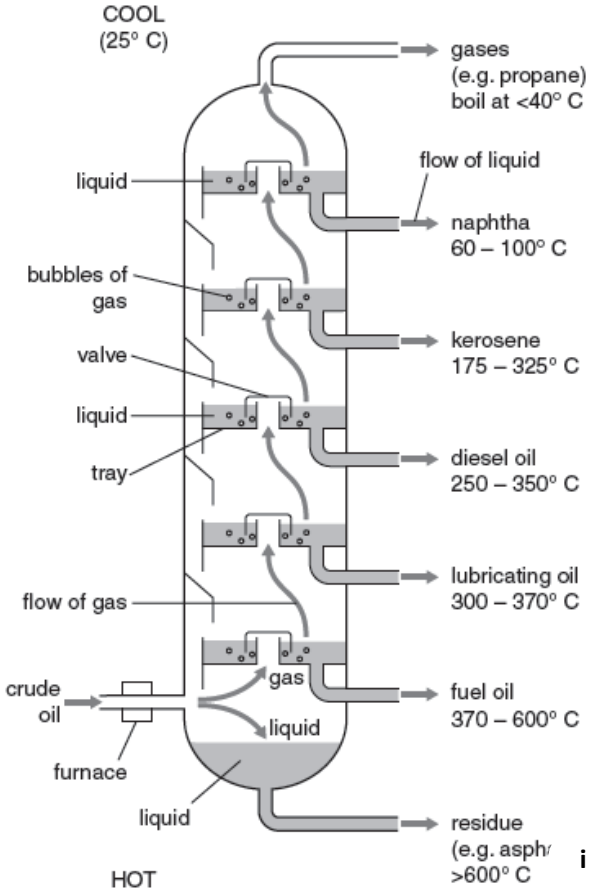

Fig.1: Fractional distillation of Crude oil

6. When a substance in the vapor reaches a height where the temperature of the column is equal to that substance's boiling point, it will condense to form a liquid. (The substance with the lowest boiling point will condense at the highest point in the column; substances with higher boiling points will condense lower in the column)

7. The trays collect the various liquid fractions.

8. The collected liquid fractions may pass to condensers, which cool them further, and then go to storage tanks, or they may go to other areas for further chemical processing

Very few of the components come out of the fractional distillation column ready for market. Many of them must be chemically processed to make other fractions. For example, only 40% of distilled crude oil is gasoline; however, gasoline is one of the major products made by oil companies. Rather than continually distilling large quantities of crude oil, oil companies chemically process some other fractions from the distillation column to make gasoline; this processing increases the yield of gasoline from each barrel of crude oil.

Chemical Processing:

Chemical processing of crude oil is to change one fraction into another. Chemical process generally has three methods: (i) Cracking, (ii) Unification and (iii) Alteration

Cracking: Cracking takes large hydrocarbons and breaks them into smaller ones. There are several types of cracking:

Thermal: Heats large hydrocarbons at high temperatures (sometimes high pressures as well) until they break apart. Steam - high temperature steam (1500 degrees Fahrenheit / 816 degrees Celsius) is used to break ethane, butane and naptha into ethylene and benzene, which are used to manufacture chemicals. visbreaking - residual from the distillation tower is heated (900 degrees Fahrenheit / 482 degrees Celsius), cooled with gas oil and rapidly burned (flashed) in a distillation tower. This process reduces the viscosity of heavy weight oils and produces tar. coking - residual from the distillation tower is heated to temperatures above 900 degrees Fahrenheit / 482 degrees Celsius until it cracks into heavy oil, gasoline and naphtha. When the process is done, a heavy, almost pure carbon residue is left (coke); the coke is cleaned from the cokers and sold. Photo courtesy Phillips Petroleum Company Catalysts used in catalytic cracking or reforming

Catalytic: Uses a catalyst to speed up the cracking reaction. Catalysts include zeolite, aluminum hydro silicate, bauxite and silica-alumina. Fluid catalytic cracking - a hot, fluid catalyst (1000 degrees Fahrenheit / 538 degrees Celsius) cracks heavy gas oil into diesel oils and gasoline. Hydrocracking - similar to fluid catalytic cracking, but uses a different catalyst, lower temperatures, higher pressure, and hydrogen gas. It takes heavy oil and cracks it into gasoline and kerosene (jet fuel).

After various hydrocarbons are cracked into smaller hydrocarbons, the products go through another fractional distillation column to separate them.

Unification: Sometimes, it needs to combine smaller hydrocarbons to make larger ones; this process is called unification. The major unification process is called catalytic reforming and uses a catalyst (platinum, platinum-rhenium mix) to combine low weight naphtha into aromatics, which are used in making chemicals and in blending gasoline. A significant by-product of this reaction is hydrogen gas, which is then either used for hydro-cracking or sold. A reformer combines chains.

Alteration: Sometimes, the structures of molecules in one fraction are rearranged to produce another. Commonly, this is done using a process called alkylation. In alkylation, low molecular weight compounds, such as propylene and butylene, are mixed in the presence of a catalyst such as hydrofluoric acid or sulfuric acid (a by-product from removing impurities from many oil products). The products of alkylation are high octane hydrocarbons, which are used in gasoline blends to reduce knocking.

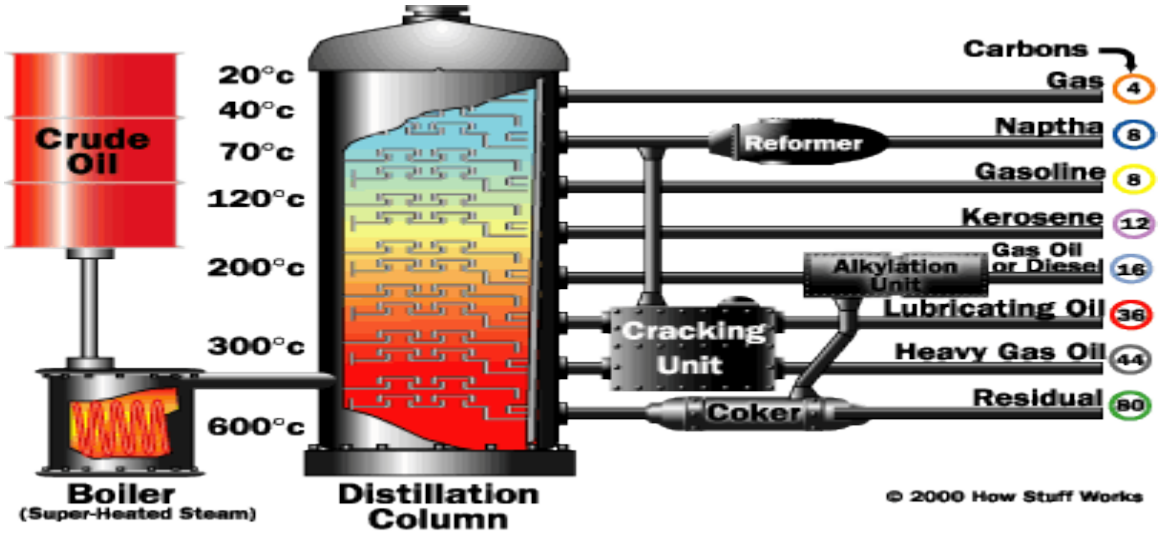

Fig. 2: Complete distillation process of Crude oil

Treating and blending the fractions: Distillated and chemically processed fractions are treated to remove impurities, such as organic compounds containing sulfur, nitrogen, oxygen, water, dissolved metals and inorganic salts.

Treating is usually done by passing the fractions through the following:

- a column of sulfuric acid - removes unsaturated hydrocarbons (those with carbon-carbon double-bonds), nitrogen compounds, oxygen compounds and residual solids (tars, asphalt)
- an absorption column filled with drying agents to remove water
- sulfur treatment and hydrogen-sulfide scrubbers to remove sulfur and sulfur compounds

After the fractions have been treated, they are cooled and then blended together to make various products, such as: gasoline of various grades with or without additives; lubricating oils of various weights and grades; kerosene of various grades; jet fuel; diesel fuel; heating oil; chemicals of various grades for making plastics and other polymers.

At the end of it all, Crude oil refinery process is a very complex and lengthy process. Although these refining processes of crude oil exhales large amount of greenhouse gases, we cannot think of our modern civilization without the useful productions from crude oil such as gasoline, jet fuel, fuel for power plants and so many.

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