Tikrit University

The College of Petroleum Processes Engineering

Petroleum Systems Control Engineering

Department

# Petroleum Refining Processes

## Fourth Class

## Lecture 10

By

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# Petroleum Refinery

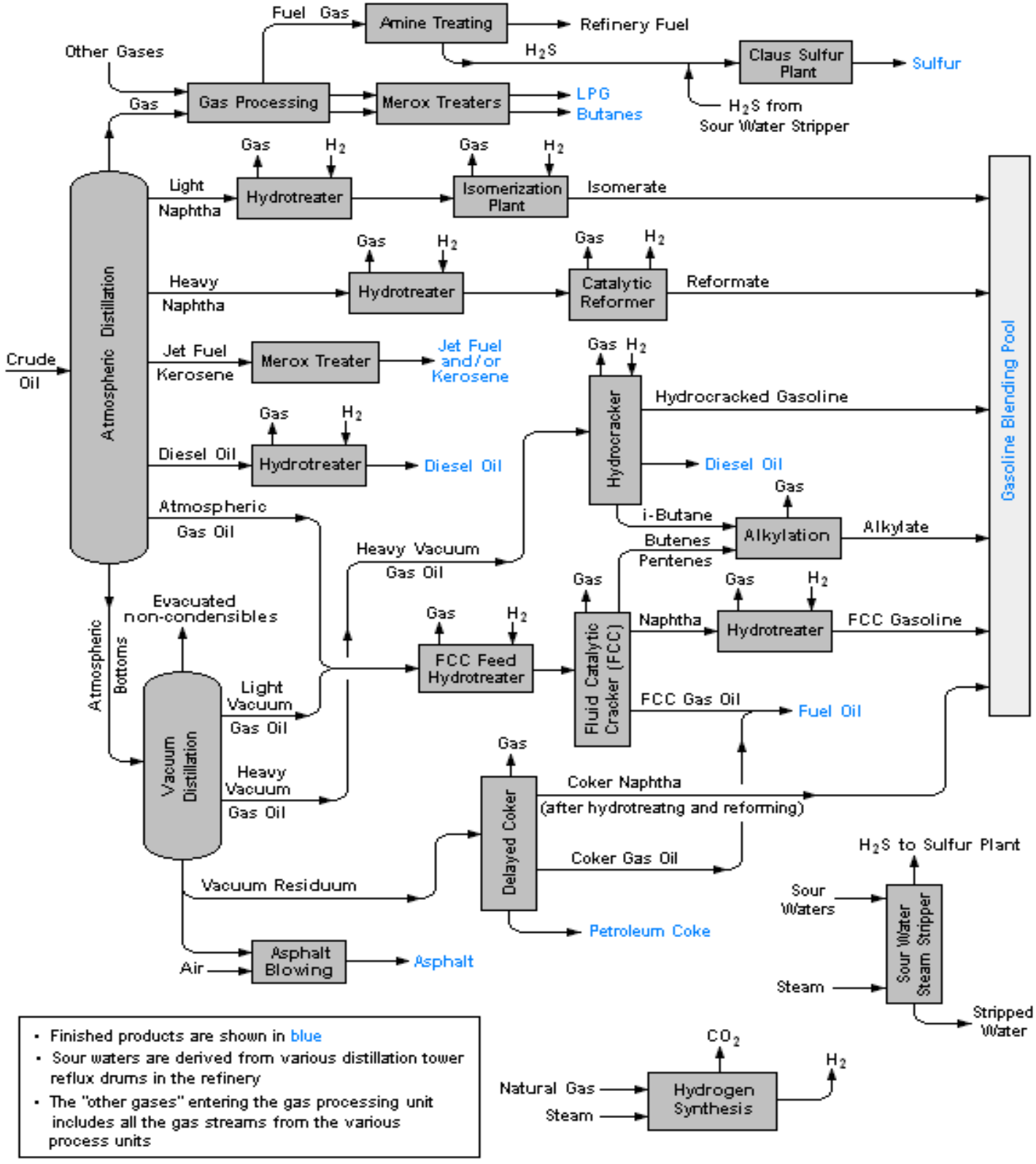


**Figure 1: Petroleum Refinery.**

# Petroleum Refinery Classification

## Petroleum refinery can be classified according to the capacity as follow:

**A small refinery**: will take in **2000 to 10000** tons of crude oil/ day. **A large refinery**: **20000 to 40000** tons/day and these are a few refineries larger than this up to **60000** tons/day. Refineries vary in **complexity** ;i.e. in the **variety of processes operated** and of **products** that are sent out.

## Petroleum refinery can be classified according to the complexity as follow:

**Simple refinery**: may make only **gasoline, diesel fuel**, and **heavy fuel**. The crude oil is distilled into:

**1) Gaseous hydrocarbons**, which are burnt as refinery fuel.

**2) Light gasoline**, which will need **sweetening, a simple chemical treatment**, and then use for automotive use except for its **low octane number.**

**3) Naphtha of very low octane number**, perhaps 40 compared with a market of 90. It is **catalytically reformed**, by which **octane number of 90 to 95** can be obtained. A simple refinery consist of a **crude oil distilling unit**, a **gasoline sweetening unit** and a **catalytic reformer**. Refineries having just this usually small of **2000 to 4000** tons/day of crude oil. **Next stage of complexity** is to added a **desulphurization** unit to treat the diesel fuel. Usually also the **growing refinery** will make **(LPG)** and some **low grade kerosene**. The **kerosene** will also need refining, at least **sweetening** to make it of **marketable odor.**

**Large Complex Refinery:** will have many more units representing more processes

**1) Vacuum Distillation**: To make a heavy distillate suitable for catalytic cracking or

hydro-cracking or manufacture of lubricating oils , and a residue which may be blown or further distilled for bitumen.

**2) Hydro-cracking**: which makes more naphtha for catalytic reforming, more diesel fuel and low sulphur fuel.

**3) Catalytic Cracking**: which makes much gas, suitable for LPG ; olefinic hydrocarbons, the feed stock for many petroleum chemicals ; and high grade gasoline.

**4) Wax Plant**: de-waxing to get wax out of oil, then de oiling of the crude wax and final purification of the wax by hydrogenation.

**5) Sweetening and Desulphurization**: for jet fuel.

**6) Alkylation unit**: to synthesize very high octane components for gasoline out of by product gases from processes (b) , (c) and the primary distillation of the crude oil.

**7) Lubricating oil refining**: special plant to remove resinous and solidifying materials from lubricating oil stocks and achieve the finished product by blending. The fluid produced at the wellhead consists usually of gas, oil, free water, and emulsified water (water–oil emulsion).

# Crude Distillation

- The first step in the refining process is the separation of crude oil into various fractions or straight-run cuts by distillation in atmospheric and vacuum towers. The main fractions or "cuts" obtained have specific boiling-point ranges and can be classified in order of decreasing volatility into gases, light distillates, middle distillates, gas oils, and residuum.
- 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**.

- Fractional distillation is useful for separating a mixture of substances with narrow differences in boiling points, and is the most important step in the refining process.
- 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.

# Atmospheric Crude Distillation Unit (CDU)

- The first process encountered in any Refinery is the Atmospheric Crude Distillation Unit CDU. In this unit the crude oil is distilled to produce distillate streams or cuts.
- These streams will either be subject to further treating downstream or become feed stock for conversion units that may be in the refinery configuration.

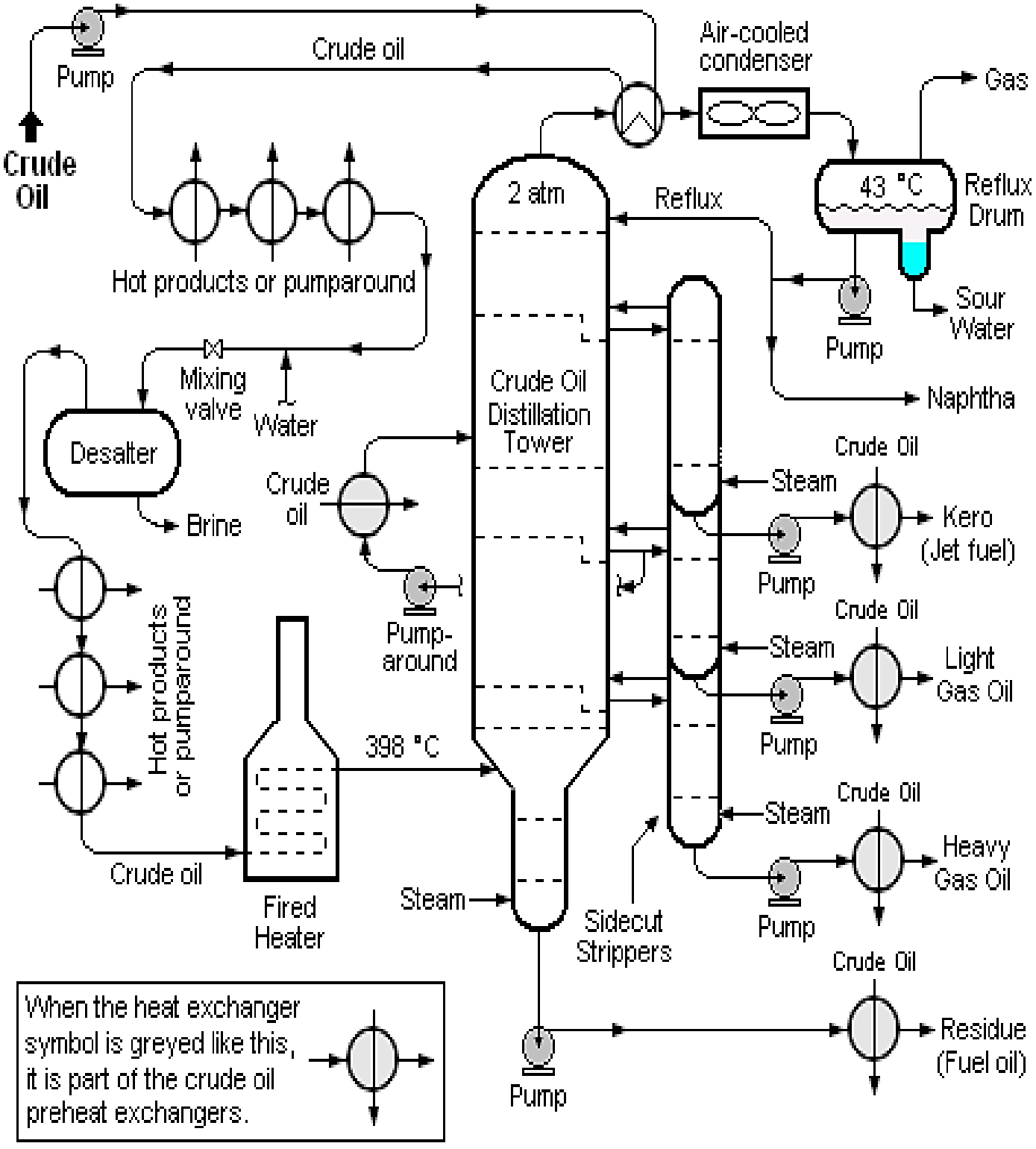


**Figure 2: A schematic Process Flow Diagram of an atmospheric CDU.**

## Typical products from the CDU are:

- Gases (Fuel Gas & LPG) C1-C4
- Light straight run naphtha (LSR) C5-C6
- Heavy straight run naphtha (HSR) C7-C10
- Kerosene (also called light distillate or jet fuel) C10-C14
- Middle distillates called diesel or light gas oil (LGO) C13-C16
- Heavy distillates called atmospheric gas oil (AGO) or heavy gas oil (HGO) C14-C18
- Light fuel oil LFO (lubricating oil) C17-C19
- Heavy fuel oil HFO C18-C20
- Crude column bottoms called atmospheric residue AR. C20+

## Main equipment in CDU

- Crude storage tanks and battery limit
- Feed pumps
- Desalter
- Preheat exchangers system
- Crude heater (Direct Fired Heater)
- Atmospheric Crude Distillation Tower
- Pump around system
- Products splitters or stabilizers
- Overhead condensers and reflux drum

The crude oil is pumped from storage tanks (battery limit area) and preheated in an exchangers train by recovering heat from the pump-around and products to a temperature of between 120-160°C.

## Preheating Exchangers System

- Crude oil is heated from storage temperature (45ºC) to about 350ºC before it is introduced to the fractionator column.
- Heat exchangers are used to raise the temperature of the crude oil utilizing the hot products (side streams) from the fractionator in addition to the pumparounds as heating mediums for heat recovery.
- The crude is first heated using the fractionator overhead (ovhd) vapor (naphtha fraction) and top pumparound (TPA).
- This is followed by the kerosene product to insures a crude temperature of 150ºC which is the temperature required for the desalting process.
- After the Desalter, crude is heated by LGO then middle pumparound (MPA) and HGO products respectively to the temperature of 210ºC.
- The hot crude is then further heated by atmospheric residue and the bottom pumparound (BPA) and to a temperature of 260ºC.
- In most cases (but not all!) the crude probably flows through the tube side of these exchangers. The crude would be easier to clean from the tubes than the shell.

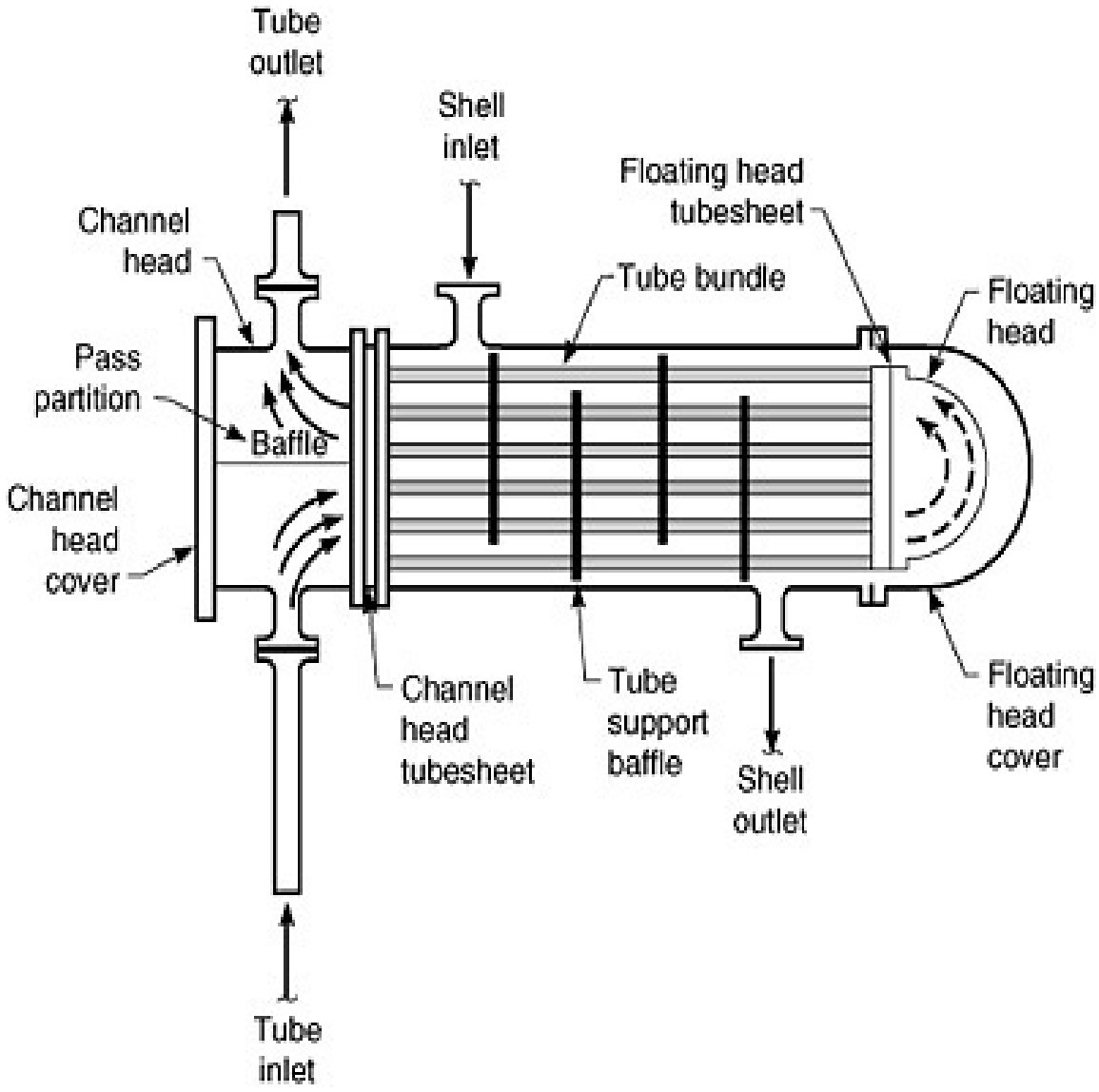


**Figure 3: Typical shell and tube preheat exchanger.**