Tikrit University

The College of Petroleum Processes Engineering

Petroleum Systems Control Engineering Department

Petroleum Refining Processes

Fourth Class

Lecture 2

Assist Teacher: Sundus H. Yousif

Classification of Crude Oil:

Classification of crude oil refers to natural and type of crude oil (**type of hydrocarbons in crude oil**) by simplified tests. Four mainly methods are used

A- Watson or UOP characterization factor (Kw):

Watson characterization factor (Kw) can be calculated from the following equation:

$$K_w = \frac{\sqrt[3]{MeABP}}{Sp.Gr\ @\ 60°F} \quad ....1$$

Kw = Watson characterization factor

MeABP = mean average boiling point temperature in Rankin = **VABP - Δ**

VABP = volume average boiling point temperatures in °F.

VABP can be calculated as the average of the five boiling temperatures at 10, 30, 50, 70 and 90 percent distilled.

Sp.Gr. 60/60°F = Specific Gravity at 15°C (60 °F) = **density crude oil @ 60°F/ density of water @ 60°F**

$$Sp.Gr\ @\ 60°F = \frac{141.5}{API + 131.5} \quad ....2$$

Crude oil classifications by Watson characterization factor as follows:

1- Kw = 12.15 – 13 paraffinic (or light) based crude oil

2- Kw = 11.1 – 12.0 mixed (or intermediate) based crude oil

3- Kw = 10 – 11.0 naphthenic (asphaltic or heavy) based crude oil

B- (API gravity):

API = American Petroleum Institute

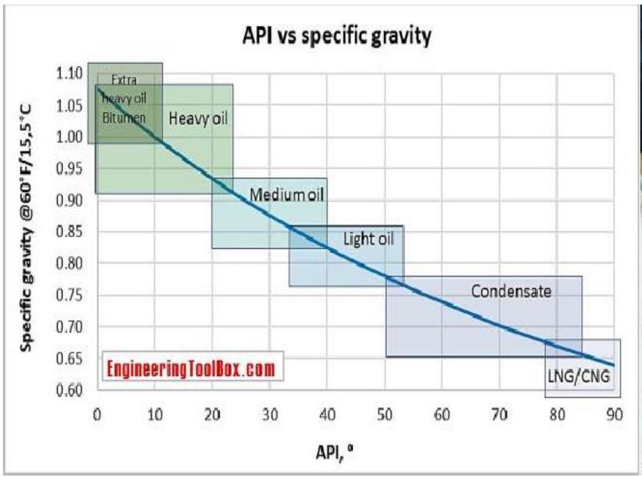
$$API = \frac{141.5}{Sp.Gr.@\ 60°F} - 131.5 \quad ....3$$

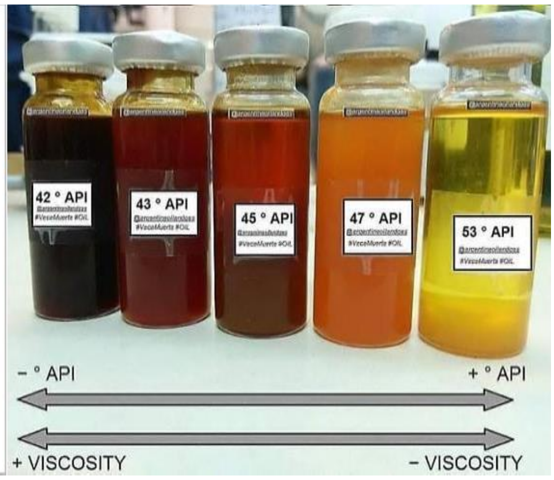
At atmospheric (1 atm), the crude oil classification will be as follows:

1- API gravity > 40 paraffinic (or light) based crude oil

2- API gravity = 33 - 40 mixed (or intermediate) based crude oil

3- API gravity < 33 naphthenic (asphaltic or heavy) based crude oil





C- Correlation Index (C.I):

This method based on the percentages of various hydrocarbons types in the crude oil which are classified into paraffinic or aromatic according to following

$$C.I = 473.7\ SG\ at\ 60F - 456.8 + \frac{48680}{ABP\ °K} \quad ....4$$

ABP: average boiling point in Kelvin

The crude oil can be classified as follow as:

1. C.I. = 0 (normal paraffinic based crude oil)

2. C.I = 0-15 (predominance of n-paraffinic crude oil)

3. C.I = 15 – 50 (paraffinic and aromatic mixture)

4. C.I > 50 (predominance of aromatic crude oil)

5. C.I = 100 benzene (Aromatic)

D- Classification by Viscosity-Gravity Constant:

The viscosity gravity constant is of particular value in indicating a predominantly paraffinic or cyclic composition. **The lower the index number**, **the more paraffinic the stock**; for example, naphthenic lubricating oil distillates have VGC = 0.876 while raffinate obtained by solvent distillation of lubricating oil distillate has VGC ~ 0.840

$$VGC = \frac{10\ Sp.Gr - 1.0752\ \log(v_{38} - 38)}{10 - \log(v - 38)} \quad ....5$$

V is the saybolt viscosity at 38° C (100°F). For oils so heavy that low-temperature viscosity is difficult to measure, an alternative formula has been proposed in which the **99°C (210°F) saybolt viscosity is used**.

$$VGC = \frac{Sp.Gr - 0.24 - 0.022\ \log(v_{99} - 35.5)}{0.755} \quad ....6$$

The Saybolt universal viscosity (SUS) is the time in seconds required for the flow of 60 ml of petroleum from a container, at a constant temperature, through a calibrated orifice.

VGC:

1) 0.70-0.79 paraffinic hydrocarbon.

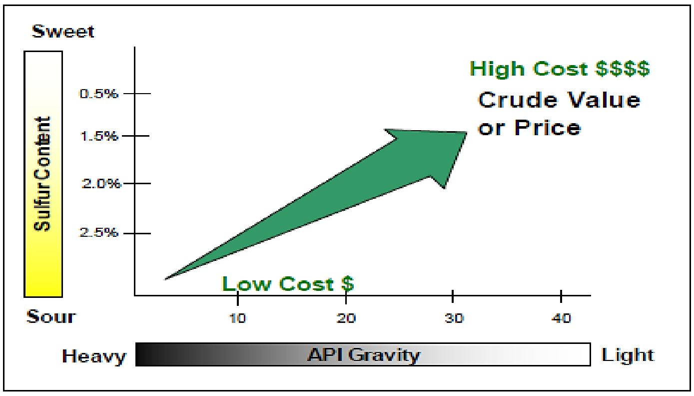
2) 0.80-0.90 naphthenic base.

3) 0.91-1.31 aromatic base.

C varies for paraffinic hydrocarbons from 0.74 0.75, for naphthenic from 0.89 to 0.94, and for aromatics from0.95 to 1.13

E - Sulfur Content:

- If crude has **less than 0.5%** sulfur content, then it will be considered as **sweet crude oil.**
- If crude has greater than 2.5% sulfur, then it will be sour crude oil.
- Crude with sulfur content between these two end points is called intermediate.



F- Technological Classification of Petroleum:

According to technological classification, the oil can be classified as:

• **Low sulfur oil** containing not more than 0.5% of the sulfur, whereby the gasoline fraction contains less than 0.1% sulfur and diesel fraction less than 0.2%.

• **High sulfur oil** containing over 2% of sulfur.

• **Low paraffinic oil** containing less than 1.5% of paraffins. This type of oil can be used for production of jet and winter diesel fuels without deparaffinization.

• **Medium paraffinic oil** containing over 1.5% and fewer than 6% of paraffins. This type of oil can be used for production of jet and summer diesel fuels without deparaffinization.

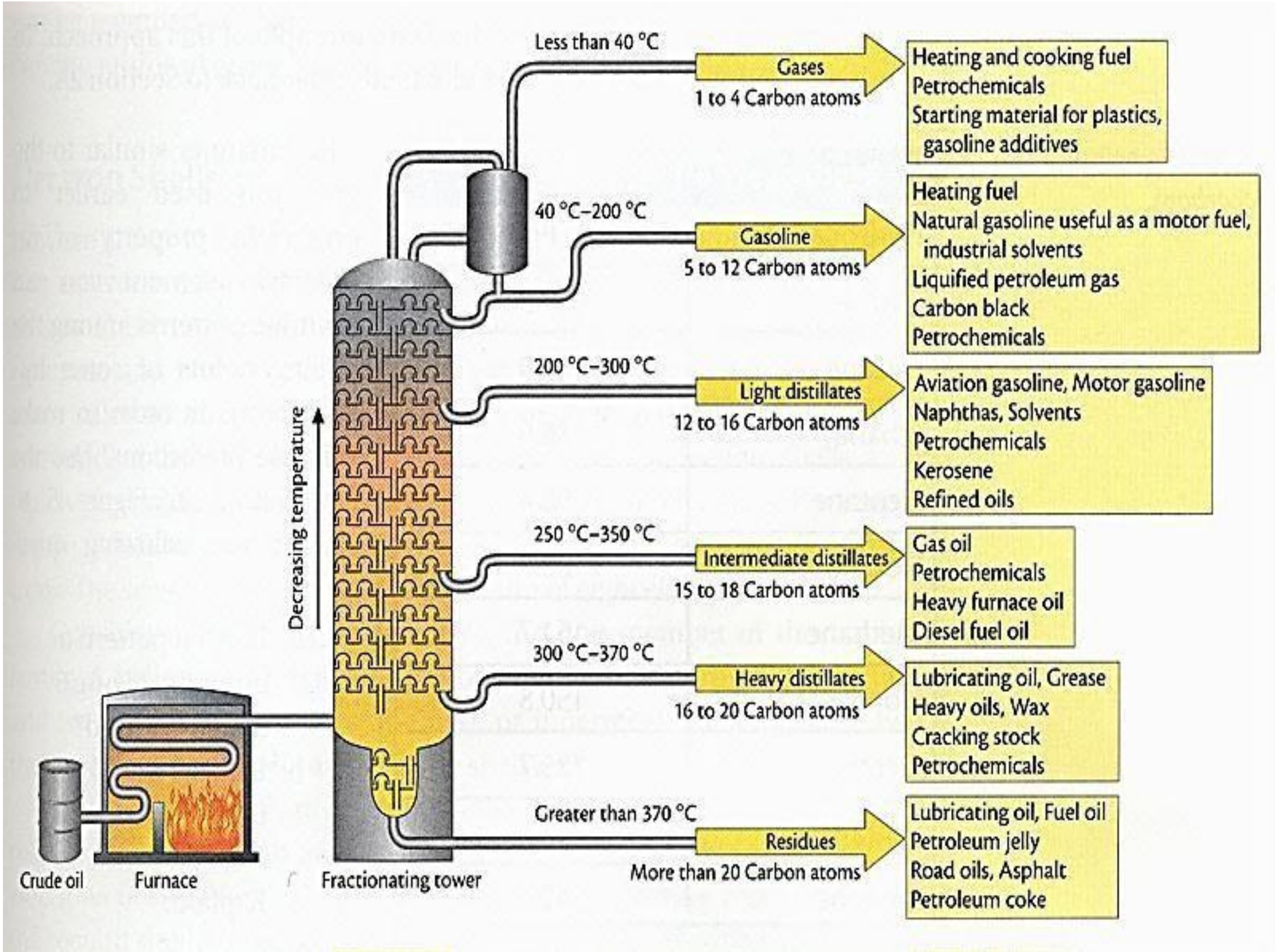
• **High paraffinic oil** containing over 6% of paraffins. This type of oil can be used for production of diesel and jet fuels only after deparaffinization.

Introduction

- Petroleum refining is a unique and critical link in the petroleum supply chain, from the wellhead to the pump. The other links add value to petroleum mainly by moving and storing it (e.g., lifting crude oil to the surface; moving crude oil from oil fields to storage facilities and then to refineries; moving refined products from refinery to terminals and end-use locations, etc.).
- Refining adds value by converting crude oil (which in itself has little end-use value) into a range of refined products, including transportation fuels. The primary economic objective in refining is to maximize the value added in converting crude oil into finished products.
- Petroleum refineries are large, capital-intensive manufacturing facilities with extremely complex processing schemes. They convert crude oils and other input streams into dozens of refined (co-)products, including:
  - ♦ Liquefied petroleum gases (LPG)
  - ♦ Gasoline
  - ♦ Jet fuel
  - ♦ Kerosene (for lighting and heating)
  - ♦ Diesel fuel
  - ♦ Petrochemical feedstocks
  - ♦ Lubricating oils and waxes
  - ♦ Home heating oil
  - ♦ Fuel oil (for power generation, marine fuel, industrial and district heating)
  - ♦ Asphalt (for paving and roofing uses).

petroleum fractions from crude distillation unit:

Typical petroleum products with their carbon atom and boiling ranges:



- Each refinery has a unique operating characteristics and economics. A refinery's performance characteristics are determined primarily by the refinery's location, vintage, availability of funds for capital investment, available crude oils, product demand (from local and/or export markets), product quality requirements, environmental regulations and standards, and market specifications.
- Most refineries in North America are configured to maximize gasoline production, at the expense of the other refined products. Elsewhere, most of the existing refining capacity and virtually all new capacity is configured to maximize distillate (diesel and jet fuel) production and, in some areas, petrochemical feedstock production, because these products are enjoying the fastest demand growth in most regions of the world.

Crude Oil Processing from Oil field to Refinery:

Crude oil collected from the wells contains sand, mud, and water as impurities which may vary from 20% to 30% by volume. Hence, raw crude is collected in a battery of treatment tanks where both treatment and storage of crude oil are carried out. Treatment steps involve:

- Removal of sand and water by gravity settling
- Chemical treatment to remove emulsified water
- Crude conditioning or stabilizing

- Well fluids are complex mixtures of different compounds of carbon and hydrogen with different densities, vapor pressure and physical characteristics.
- As the well fluids travel from the reservoir to the production facility, it experiences pressure and temperature reduction.
  - The characteristics of the well stream continuously changes with the evolving gas from the liquid as the pressure reduces.
  - The separation of these phases is one of the basic operations in production, processing and treatment.

Wellhead and Manifold:

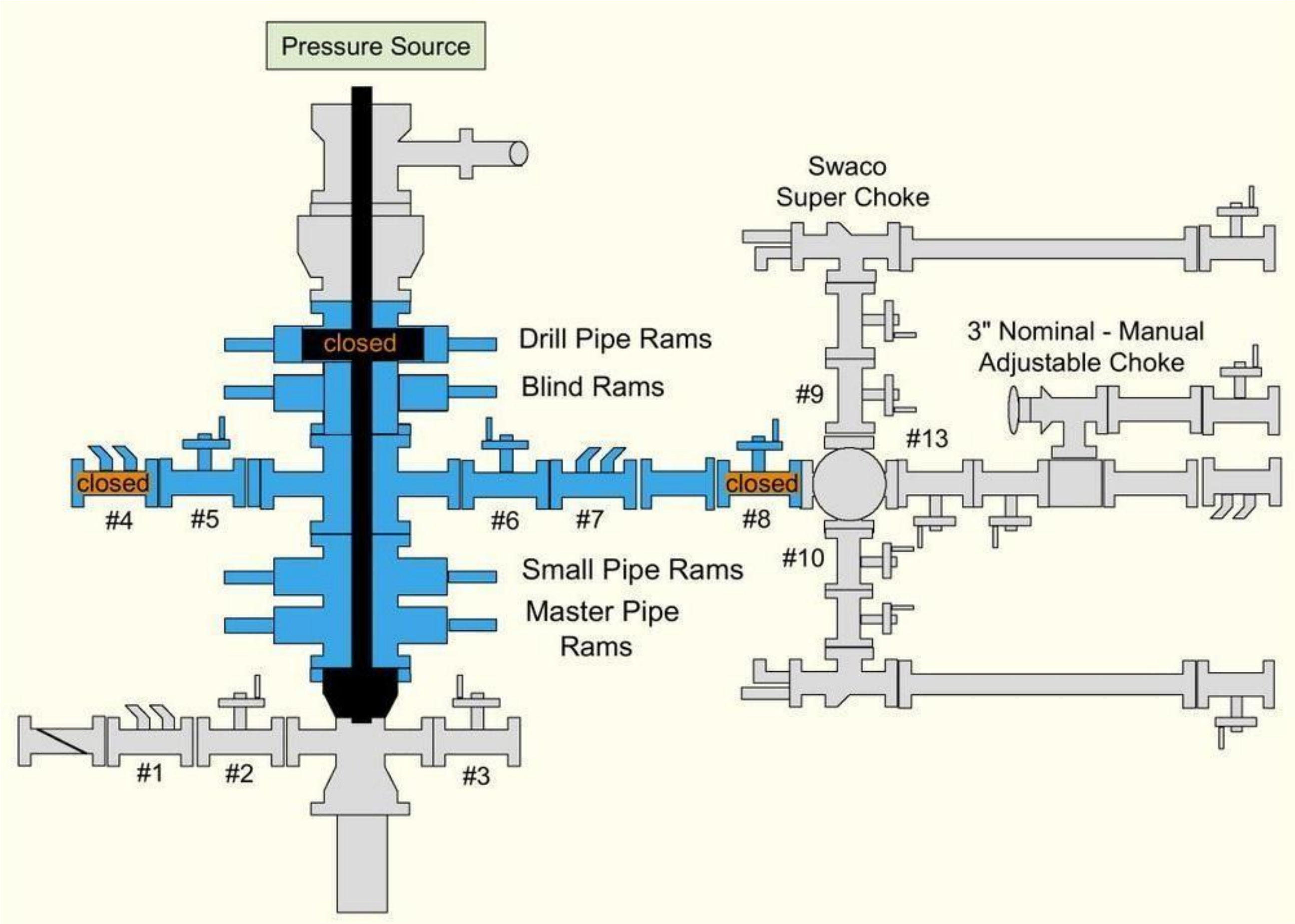


Figure 1: Wellhead Manifold.

- The oil production system begins at the wellhead, which includes at the least one choke valve, whose percentage opening determines the flowrate from the wells.
- Most of the pressure drop between the well flowing tubing head pressure (FTHP) and the separator operating pressure occur across the choke valve.
- Whenever two or more wells are installed on a wellhead platform, a production manifold as well as test manifold should be installed to gather fluid from the wells prior to be processed in separator or exported via pipeline.
- The test manifold is provided to allow an individual well to be tested either via a Test Separator or Multiphase Flow Meter (MPFM).