Tikrit University

The College of Petroleum Processes Engineering

Petroleum Systems Control Engineering

Department

Properties of Petroleum & Natural Gas

Third Class

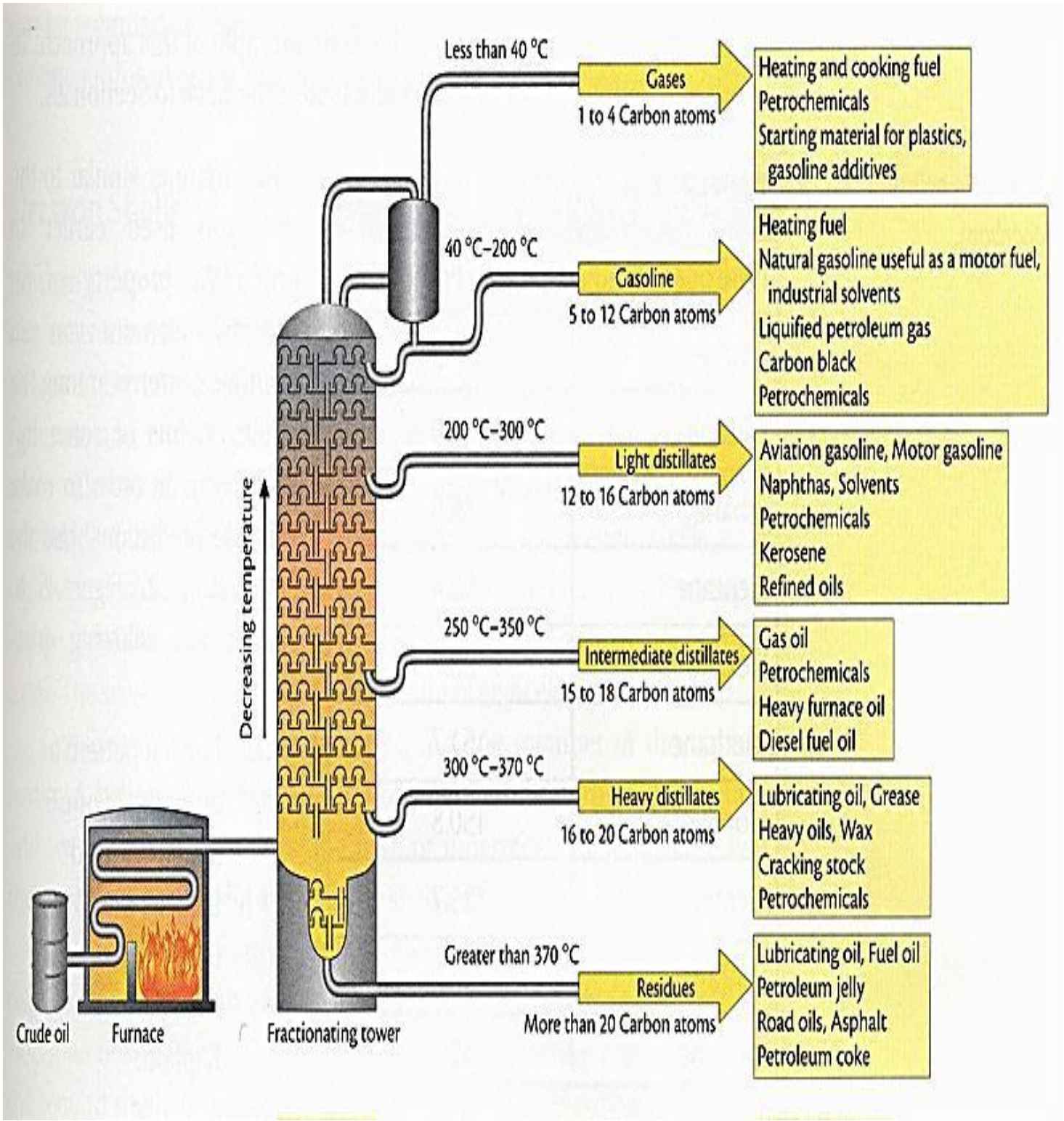
Lecture 6

By

Jasim I. Humadi

Petroleum fractions from crude distillation unit

Typical petroleum products with their carbon atom and boiling ranges:



Overhead Natural Gases

(C1-C2 methane and traces of ethane)

LPG (C3 - C4)

• Liquefied petroleum gas derived from crude oil refining or natural gas fractionation.

• **LPG** contains: ethane, ethylene, propane, propylene, normal butane, butylene, isobutane and isobutylene.

• For convenience of transportation, these gases are liquefied through pressurizing.

• **LPG** as a **liquid is colorless**, pure LPG has **no smell**, but for safety reasons an odorant agent, usually a mercaptan, is added during manufacture to aid detection at very low concentrations.

• **LPG** has a big advantage over natural gas, which can be liquefied only at a very low temperature and high pressure.

• **LPG** as a **liquid is 250 times denser than LPG as vapor**, so a large quantity can be stored in a relatively small volume.

• **The heating value of LPG** on a volume basis is significantly higher (propane, 95 MJ/m3; butane, 121 MJ/m3) compared with that of natural gas **(38 MJ/m3)**.

• **LPG uses** in central heating, space heating, and hot water supply, as well as in a large number of appliances, such as ovens, stovetops, and refrigerators in homes, hotels, and restaurants.

• The absence of sulfur and very low levels of nitrogen oxides (NOx) and particulate emissions during its combustion make **LPG a most environmentally friendly source of energy.**

• **Automotive LPG**, or auto-gas, refers to the LPG used in automotive applications.

• The disadvantage is that LPG has a lower heating value per unit volume, and thus the vehicle has to refuel more frequently.

• **LPG** used in automobiles is stored in liquid form in an onboard steel cylinder.

• More than 4 million automobiles use LPG worldwide at present.

Naphtha (C5-C10)

Total naphtha TN is the lightest liquid distillate product of crude distillation consisting of **C5 to C10** hydrocarbons boiling in the 38°C to 180°C range.

Naphtha may be classified by its boiling range or by its end use:

• Light straight run (LSR) naphtha.

• Wide straight run (WSR) naphtha.

• Petrochemical naphtha.

LSR with a boiling range of C5 to 80°C. It consists mainly of C5 and C6 hydrocarbons. It is highly paraffinic. The paraffin content of light naphtha is greater than 80 vol %.

- **LSR** naphtha is a preferred feedstock for refinery isomerization unit to make a light gasoline blending component.
- **LSR** naphtha has a low RON of approximately 60.
- In the isomerization unit, Isomerization of C5 and C6 normal paraffins to isoparaffins increases RON by 18 to 22 numbers.
- **Isomerate** is a very useful blend component to control gasoline distillation and to reduce high aromatic content reformate blending in gasoline.

WSR is a (C5-180°C)

- A significant part of WSR is used as petrochemical naphtha or as a feedstock for the catalytic reforming unit for the production of a motor gasoline blend component.

Petrochemical naphtha

- **is blended** from the straight run naphtha and hydrocracker naphtha.
- Naphtha used as petrochemical feedstock must be highly paraffinic (minimum 70 vol %) with low aromatic content (less than 11 vol %).

Gasoline (C5 - C10 - C12)

- **Gasoline** is a volatile flammable liquid hydrocarbon mixture used as a fuel especially for in spark-ignited internal combustion engines.
- **Blended Gasoline** is a mixture of several products such as reformate, isomerate, alkylate, hydrocracked gasoline, catalytic cracker gasoline and coker gasoline.
- **Gasoline** has a boiling range of 38 to 200°C

• **Physical description**: Is a clear, volatile liquid

• **Chemical description:** a complex mixture of hydrocarbons, averaging 5-12 carbon atoms per molecule. Virgin gasoline usually contains: **50 percent alkanes (paraffins), 40 percent cyclic alkanes (naphthenes) and 10 percent aromatics.**

• **Flash point: -45°C.**

• **Density: 0.64 to 0.72.**

• **Auto-ignition temperature: 495°F (257°C).**

• **Vapor density: 3 to 4 times that of air.**

• **Viscosity: Slightly less than water**

• **Average boiling range: 90-363°F (32-184°C).**

Gasoline finished product is classified by octane ratings into three grades:

- **Regular gasoline**: Gasoline having antiknock index, i.e. octane rating, greater than or equal to **85 and less than 88**.

- **Mid-grade gasoline**: Gasoline having octane rating, greater than or **equal to 88 and less than or equal to 92**
- **Premium or super gasoline**: Gasoline having octane rating **greater than 93**.

Kerosene (C10 – C14)

- **Kerosene** is a fraction of crude oil boiling between **174 and 260°C**.
- It is heavier than naphtha and gasoline cut but lighter than diesel cut.
- The yield of kerosene from a medium gravity crude oil such as light Arabian is approximately 16 vol %.

Physical Description: A pale yellow or clear oily liquid.

Chemical Description:

• Kerosene is a complex mixture of hydrocarbons, usually containing C**10 to C16 carbon atoms** per molecule with the **average being C12**. The average chemical composition by percent is: 35 **percent alkanes (paraffins), 60 percent cyclic alkanes (naphthenes) and 15 percent aromatics**.

• Flash point: l00°F-165°F (38-74°C).

• Auto-ignition temperature: 444°F (229°C).

• Density range: 0.73 to 0.820

• Vapor density: 4.5 times that of air.

• Pour point: 0°F (-18°C).

• Average boiling range: 345-510°F (174-260°C)

• **Kerosene** used in space heaters, cook stoves, water heaters and suitable for use as a light source.

- **Kerosene** used in aircrafts is called **"aviation turbine fuel." Kerosene was considered as aviation fuel because of:**

• its high flash point: A higher flash point allowed safer handling, transportation, and storage of fuel.

• lower volatility compared with that of naphtha.

• **Kerosene** has a very low freezing point, allowing planes to fly at great altitudes.

Two main grades of turbine fuels are in use for civil commercial aircrafts:

Jet A-1 and Jet A. Another grade of jet fuel called **Jet B** is a wide-cut kerosene (a blend of naphtha and kerosene) that is used only in very cold ambient conditions.

Jet A-1 is a kerosene cut suitable for most turbine engine aircrafts. It has a minimum flash point of 100°F and a maximum freeze point of –47°C (–52.6°F). Jet A-1 meets the specifications of ASTM D 1655 (Jet A-1).

Jet A is identical to Jet A-1 except that it has a higher freeze point maximum of –40°C. It meets ASTM D 1655 (Jet A) specifications. Jet A is used within the United States by domestic and international airlines.

Jet B is a wide-cut distillate fuel containing naphtha and kerosene fractions.

• It can be used as an alternative to Jet A-1, but it has a lower flash point and higher flammability.

• It is more difficult to handle. It is used in very cold weather operations.

• It is generally produced to Canadian specifications CAN/CGSB 3.23.

Military Jet Fuel Specifications

The major difference between U.S. military fuels and commercial fuels is the use of certain additives, such as anti-icing, corrosion inhibitors, lubricity improvers, antioxidants, thermal stability

improvers, and conductivity improvers.

JP-4: blend of 60 vol % light straight run naphtha, medium straight naphtha, and 40 vol % straight run kerosene. JP-4 has corrosion inhibitor and anti-icing additives. It meets the requirements of U.S. military specifications MIL-DTL-5624U grade JP-4. It also meets requirements of British specifications DEF STN 91-88 AVTAG/FSII. JP-4 can be considered the military equivalent of Jet B.

JP-5: is a high flash kerosene meeting the requirements of U.S. military specifications MIL–DTL-5624U grade JP-5. JP-5 also meets the requirements of British specifications DEF STN 91-87 AVTUR /FSII. JP-5 is mainly used by the U.S. Navy for its aircrafts based on aircraft carriers. Its high flash point provides a higher degree of safety in fuel handling.

JP-7: is a highly refined, high thermal stability fuel developed in the 1960s to meet the high heat sink demand of supersonic air crafts and **missiles.**

• It is thermally stable to 550°F.

• It has high flash, **very low aromatic content** (maximum 5 percent), a high hydrogen content, and a high heat of combustion.

• It is blended from kerosene coming from distillate hydrocracker and straight run desulfurized kerosene blend components. A U.S. study showed that a turbine fuel with thermal stability near that of JP-7 can be made from a 50:50 blend of naphthalic straight run kerosene and hydrocracker kerosene.

Diesel Fuel (C12 – C20) Gasoil (LGO and HGO)

(boiling range 260-425°C)

The term diesel is used for motor vehicle fuel used in compression-ignited engines. Rudolf Diesel invented the compression-ignited engine in 1892.

High-speed diesel engines (1200 r/min and greater) are used to power trucks, buses, tractors, farm machinery, railroad locomotives, passenger cars, yachts, pumps, compressors and small electric generators.

• **Physical Description:** A yellow viscous liquid.

• **Chemical Description**: A complex mixture of hydrocarbons with C**12 to C20** carbon atoms per molecule, with the average being C15. The average chemical composition, by percent, is: 30 percent alkanes (paraffins), 45 percent cyclic alkanes (naphthenes) and 25 percent aromatics.

• The quality of diesel fuels can be **expressed as cetane number or cetane index**. The cetane number (CN) is expressed in terms of the volume percent of cetane (C16H34) which has high ignition (CN = 100) in a mixture with alpha-methyl-naphthalene (C11H10) which has low ignition quality (CN = 0).

Diesel fuel includes:

No.1 diesel (Super-diesel) which has cetane number of 45 and it is used in high speed engines, trucks and buses.

No.2 diesel has CN: 40. It is especially suitable for use in applications with conditions of varying speed and load.

No.4 a heavy distillate fuel or blend of distillate and residual oil, for use in low and medium speed diesel engines in applications involving predominantly constant speed and load have higher boiling ranges up to 400 ° C and lower cetane numbers.

Fuel Oil (LFO and HFO) C20+

Physical Description: Very viscous, dark colored liquid.

Chemical Description: A complex mixture of heavy molecular weight hydrocarbons, averaging **about 30 carbon atoms per molecule**. The average chemical composition is: 15 percent alkanes (paraffins), 15 percent polar compounds, containing nitrogen, oxygen, or sulfur, 25 percent aromatics, 45 percent cyclic alkanes (naphthenes).

The fuel oils are mainly:

No. 1 fuel oil is similar to kerosene.

No. 2 fuel oil is very similar to No. 2 diesel fuel.

Heavier grades of No. 3 and 4 are also available.

Residual Fuel Oil

It is mainly composed of vacuum residue. Critical specifications are viscosity and sulphur content. Low sulphur residues are in more demand in the market.

Lube Oil

Lubricants are based on the viscosity index. Paraffinic and naphthenic lubricants have a finished viscosity index of more than 75.

Asphalt

Asphalt is an important product in the construction industry and comprises up to 20% of products. It can be produced only from crude containing asphaltenic material.

Petroleum Coke

Carbon compounds formed from thermal conversion of petroleum containing resins and asphaltenes are called petroleum cokes. Fuel grade coke contains about 85% carbon and 4% hydrogen. The balance is made up of sulphur, nitrogen, oxygen, vanadium and nickel.

Disadvantages of the presence of asphaltenes in crude oil

• Precipitate inside the pores of rock formations, well heads and surface processing equipment

• Transportation problems because they contribute to gravity and viscosity increases of crude oils

• Coke formation and metal deposition on catalyst surface causing catalyst deactivation