# Republic of Iraq

# Ministry of Higher Education and Scientific Research

# Al-Mustaqbal University College

# Chemical Engineering and Petroleum Industries Department

## Subject: Oil and Gas Field Processing

## 3rd Class

## Lecture 7

## Cracking

Cracking means heating of higher boiling petroleum fractions like heavy fuel oil at high temperature (above decomposition temperature) and pressure to produce lower boiling lighter fractions. It is an endothermic reaction.

The main application of cracking is for production of gasoline from gas oil. It is also done to produce olefins (for petrochemicals production) from gas oil and naphtha, lower viscosity furnace oil (visbreaking) and coke. Important chemical reaction in thermal cracking (non catalytic) which is carried out at comparatively higher pressure (P) (1-7) atm and temperature (450-750) $^{o}$C by heating the feed are decomposition, isomerisation and polymerization. First, the higher paraffin (n-decane) decomposes to lower paraffin and an olefin.

$$CH_3(CH_2)_8CH_3 \longrightarrow CH_3(CH_2)_4CH_3 + CH_3.CH_2CH=CH_2$$

## Types of Cracking:

**Table** Thermal cracking process

| |
|---|
| *Visbreaking* |
| Mild heating 471–493 °C (880–920 °F) at 50–200 psig |
| Reduce viscosity of fuel oil |
| Low conversion (10%) at 221 °C (430 °F) |
| Heated coil or soaking drum |
| *Delayed coking* |
| Moderate heating 482–516 °C (900–960 °F) at 90 psig |
| Soak drums 452–482 °C (845–900 °F) |
| Residence time: until they are full of coke |
| Coke is removed hydraulically |
| Coke yield ~ 30 wt% |
| *Fluid coking and flexicoking* |
| Severe heating 482–566 °C (900–1050 °F) at 10 psig |
| Fluidized bed with steam |
| Higher yields of light ends |
| Less coke yield (20% for fluid coking and 2% for flexicoking) |

**Visbreaking Process:**

Visbreaking is a mild thermal cracking of vacuum or atmospheric residues to produce light products and 75–85% cracked material of lower viscosity that can be used as fuel oil.

Feed Sources

The feed to visbreaker can be either:

- Atmospheric residue (AR)
- Vacuum residue (VR)

Vacuum residue is the heaviest distillation product and it contains two fractions: heavy hydrocarbons and very heavy molecular weight molecules, such as asphaltene and resins.

Visbreaking Reactions:

The possible reactions in visbreaking are:

- Paraffinic side chain breaking which will also lower the pour point;
- Cracking of naphthens rings at temperature above 482 °C (900 °F);
- Coke formation by polymerization, condensation, dehydrogenation and dealkylation; and
- Further cracking will be the result of asphaltene and coke leaving the liquid phase (delayed coking)

Product Yield and Properties

Four products are produced in the visbreaking process: gases (C4), Naphtha C5 - 166 °C (C5 -330 F), gas oil 166–350 °C (330–660 F) and residue or tar 350+ °C (660+ F). Typical yields are given in Table below.

Typical yields of visbreaking process

| Product | wt% of charge |
|---|---|
| Gases ($C_4^-$) | 2–4 |
| Naphtha ($C_5$–330 °F) | 5–7 |
| Gas oil (330–660 °F) | 10–15 |
| Tar (660+ °F) | 75–85 |

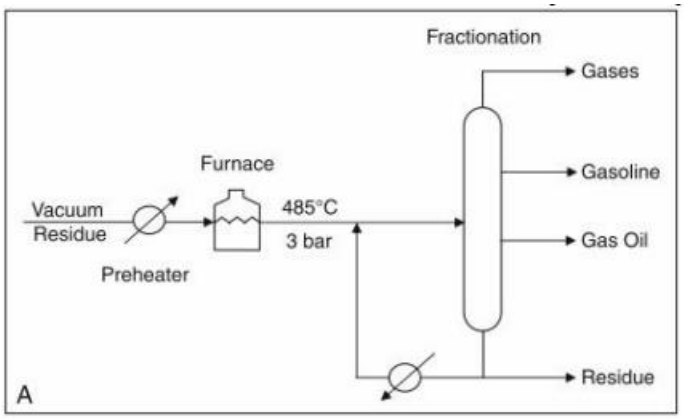
Process Description

There are two types of visbreakers: coil visbreaking, in which thermal cracking occurs in the coil of the furnace, and the soak visbreaker, in which cracking occurs in a soak drum.

**Coil Visbreaker**

Vacuum or atmospheric residue feedstock is heated and then mildly cracked in the visbreaker furnace. Reaction temperatures range from 850 to 900 F (450 to 480 °C), and operating pressures vary from as low as 3 bar to as high as 10 bar. As shown in Figure A, coil furnace visbreaking is used and the visbroken products are immediately quenched to stop the cracking reaction. The quenching step is essential to prevent coking in the fractionation tower. The gas oil and the visbreaker residue are most commonly used as quenching streams.

After quenching, the effluent is directed to the lower section of the fractionator where it is flashed. The fractionator separates the products into gas, gasoline, gas oil and visbreaker tar (residue).


Fractionation
Gases
Gasoline
Gas Oil
Residue
Furnace
Vacuum
Residue
Preheater
485°C
3 bar
A