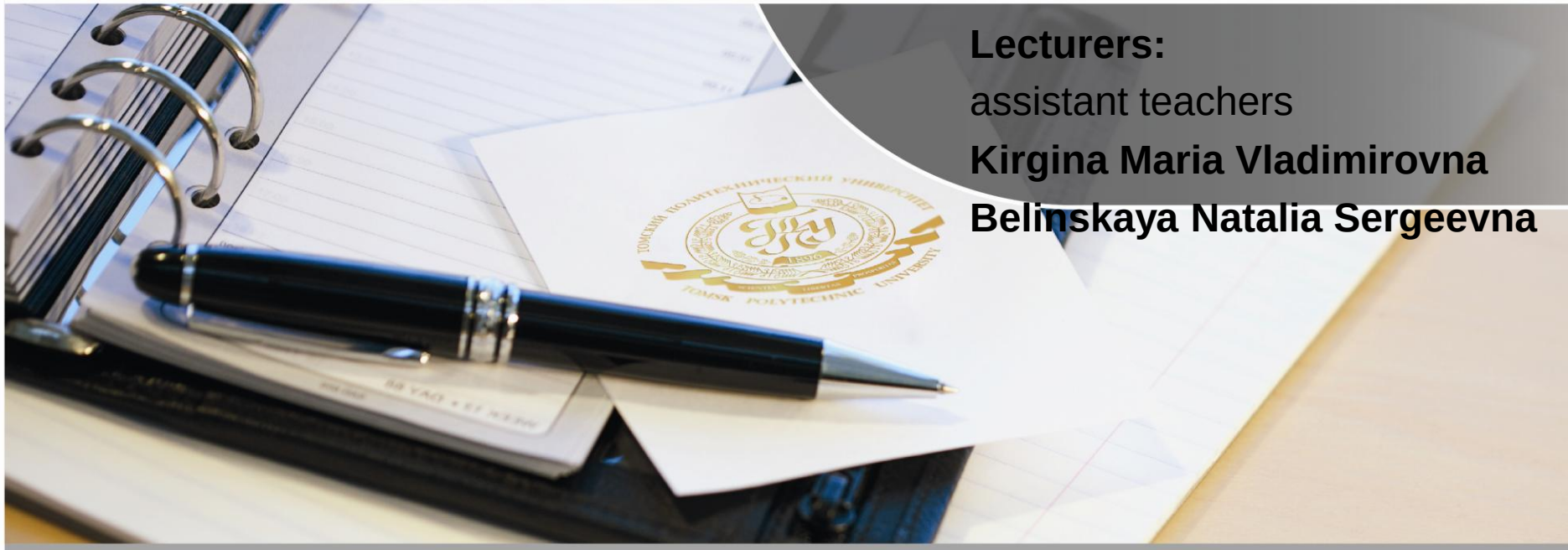
НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Fundamentals of Petroleum Refining
Introduction



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Introduction

The recent price rise of crude oil has affected the refining industry in three ways:

- an increased search for fuel products from non-fossil sources
- the development of better methods to process tar sand, coal gasification and synthesis of fuels by Fischer–Tropsch technology
- the initiation of long-term plans to look for renewable energy sources.

crude oil prices are still a cheap source for transportation fuels and petrochemicals

Classification of the refining processes

Table 1.

Physical separation	Chemical conversion	
	Catalytic	Thermal
Distillation	Reforming	Delayed coking
Solvent deasphalting	Hydrotreating	Flexicoking
Solvent extraction	Hydrocracking	Visbreaking
Solvent dewaxing	Alkylation	
	Isomerization	

Refining Processes. Physical Separation Processes

Table 2.

	Yield (wt %)	True boiling temperature (ºC)
Atmospheric distillation		
Refinery gases (C_1 – C_2)	0.10	–
Liquid petroleum gases (LPG)	0.69	–
Light straight run (LSR)	3.47	32 – 82
Heavy straight run (HSR)	10.17	82 – 193
Kerosene (Kero)	15.32	193 – 271
Light gas oil (LGO)	12.21	271 – 321
Heavy gas oil (HGO)	21.10	321 – 427
Vacuum distillation		
Vacuum gas oil (VGO)	16.80	427 – 566
Vacuum residue (VR)	20.30	+566

Refining Processes. Physical Separation Processes

Solvent Deasphalting

- carbon is rejected from heavy petroleum fraction such as vacuum residue
- propane in liquid form is used to dissolve the whole oil
- the deasphalted oil (DAO) has low sulphur and metal contents
- this oil is used as feedstock for lube oil plant or cracking units

Solvent Extraction

- lube oil stock is treated by a solvent, such as N-methyl pyrrolidone (NMP), which can dissolve the aromatic components in one phase (extract) and the rest of the oil in another phase (raffinate)

Solvent Dewaxing

- the raffinate is dissolved in a solvent (methyl ethyl ketone, MEK)
- the solution is gradually chilled
- high molecular weight paraffin (wax) is crystallized
- the remaining solution is filtered

Refining Processes. Chemical Catalytic Conversion Processes

Catalytic Reforming

- **feed** is naphtha fraction (C6–C10)
- **catalyst** is platinum metal supported on silica or silica base alumina
- the produced reformate has a **higher octane number** than the feed
- reformate is used in **gasoline formulation** and as a **feedstock for aromatic production** (benzene–toluene–xylene, BTX)

Hydrotreating

- the cleaning of **petroleum fractions** from **impurities** such as sulphur, nitrogen, oxy-compounds, chloro-compounds, aromatics, waxes and metals using hydrogen
- **catalyst** is cobalt and molybdenum oxides on alumina matrix

Catalytic Cracking

- **feed** is vacuum gas oil
- **catalyst** is a zeolite base for the cracking function
- **product** is gasoline, gas oil and refinery gases

Refining Processes. Chemical Catalytic Conversion Processes

Catalytic Hydrocracking

- **feed** is atmospheric residues (AR) and vacuum gas oils (VGOs)
- **catalyst** is composed of a zeolite catalyst for the cracking function and rare earth metals supported on alumina for the hydrogenation function
- **products** are kerosene, jet fuel, diesel and fuel oil

Alkylation

- **feed** is isobutane and olefins such as butylene (C4)
- **catalyst** is sulphuric acid or hydrofluoric acid
- **product** is gasoline range alkylate
- the hydrocarbons and acid react in liquid phase

Isomerization

- **feed** is light naphtha (low octane number hydrocarbons (C4, C5, C6)
- **catalyst** is a Pt-zeolite base
- **product** is high octane number products

Refining Processes. Thermal Chemical Conversion Processes

Delayed Coking

- thermal cracking of **vacuum residue**
- **product** is coke and lighter products such as gases, gasoline and gas oils
- 2 types of coke can be produced: sponge and needle
- the vacuum residue is heated in a furnace and flashed into large drums where coke is deposited on the walls of these drums, and the rest of the products are separated by distillation

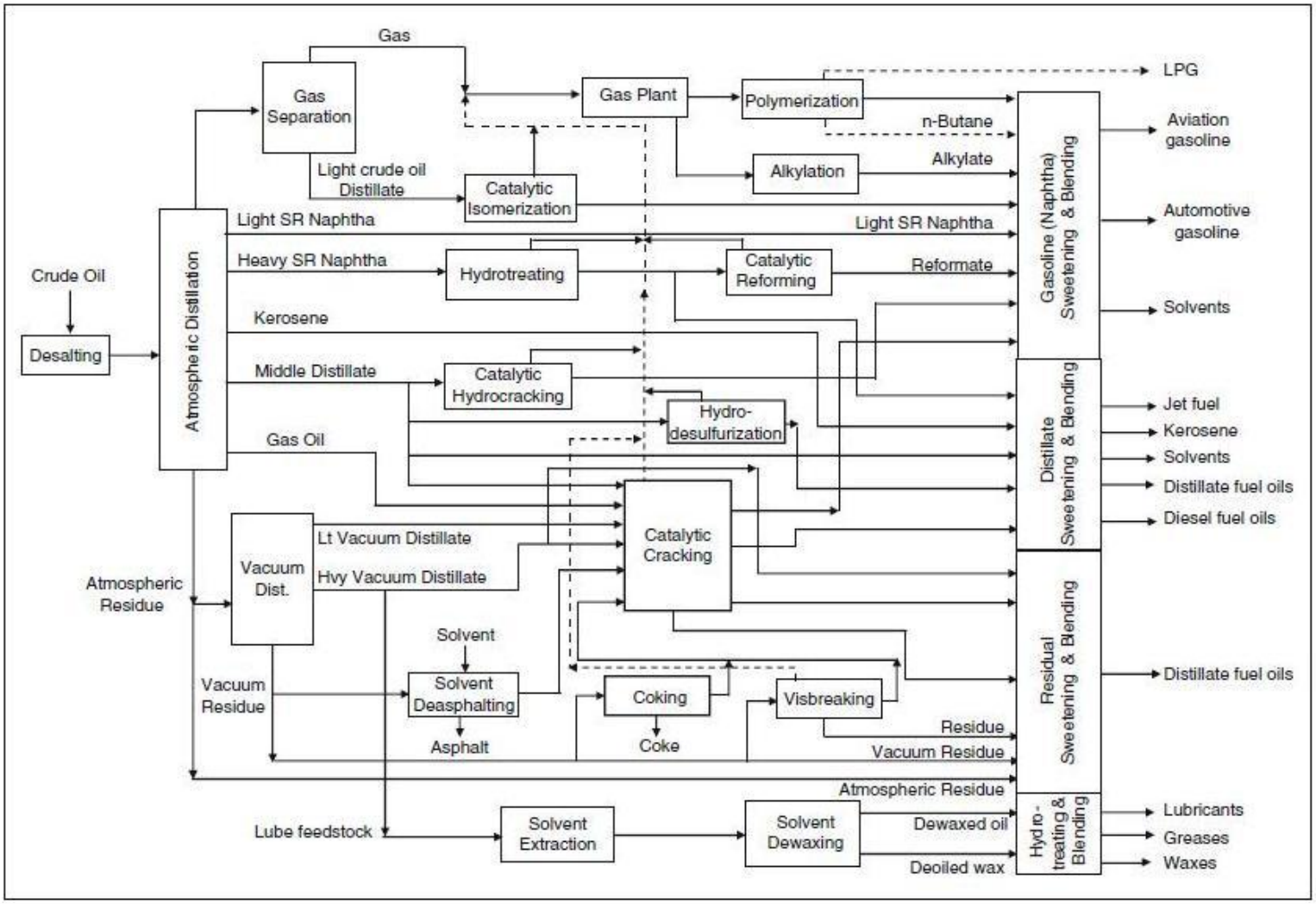
Flexicoking

- coke is gasified into fuel gas using steam and air
- the **products** are gases, gasoline and gas oils with very little coke

Visbreaking

- break the high viscosity and pour points of vacuum residue
- the residue is either broken in the furnace coil (coil visbreaking) or soaked in a reactor for a few minutes (soaker visbreaker)
- the **products** are gases, gasoline, gas oil and the unconverted residue

Figure 1. The modern refinery



Refinery Configuration

The refinery configuration can range from single topping for crude distillation to high conversion refinery for petro-refinery.

Factors

- Type of Products
- Environmental Regulation
- Crude Assay and Quality
- Refinery-petrochemical Integration
- Development of New Technology

Refinery Configuration. Type of Products

- refining is carried out by increasing the hydrogen/carbon (H/C) ratio
- hydrogenation processes such as hydrotreating, hydrocracking or by carbon rejection processes such as thermal cracking and fluid catalytic cracking, catalytic reforming, isomerization and alkylation

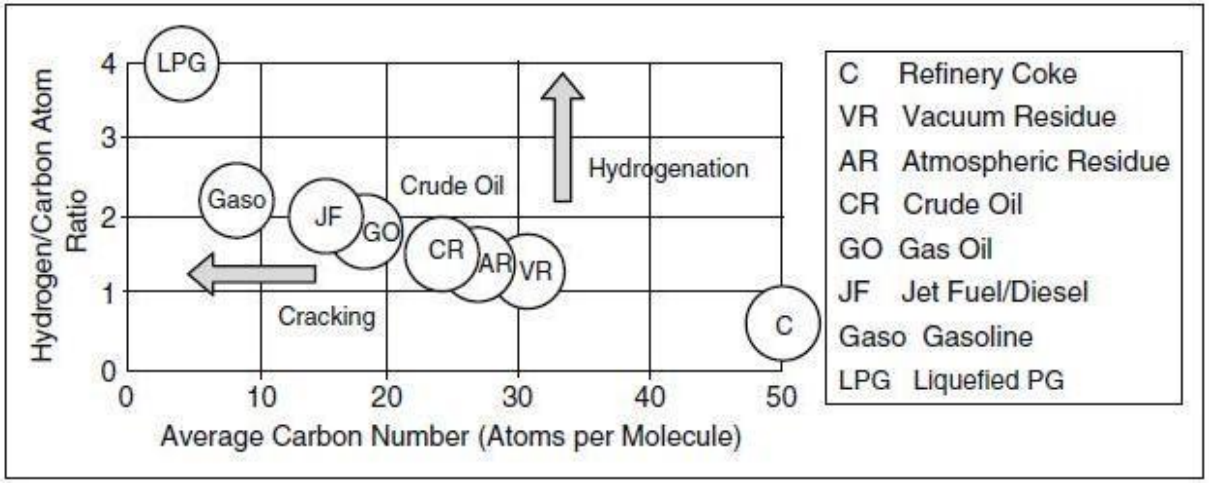


Figure 2. Petroleum products

Refinery Configuration. Environmental Regulation

- a **low level of contaminants** like sulphur
- units which can produce **ultra low sulphur products**
- **clean fuels** are gaining great interest, and completely **new refinery configurations** are now being introduced to produce clean fuels from new refinery feeds and configurations
- additional units have been added to existing refineries to handle **untreated gas emissions** and **refinery waste water** due to changes in environmental regulations

Refinery Configuration. Crude Assay and Quality

- crude quality is getting heavier worldwide
- existing refineries, which are designed to handle normal crudes are being modified to handle heavy crude
- the crude assay will determine the yields of different cuts and consequently, the refinery configuration

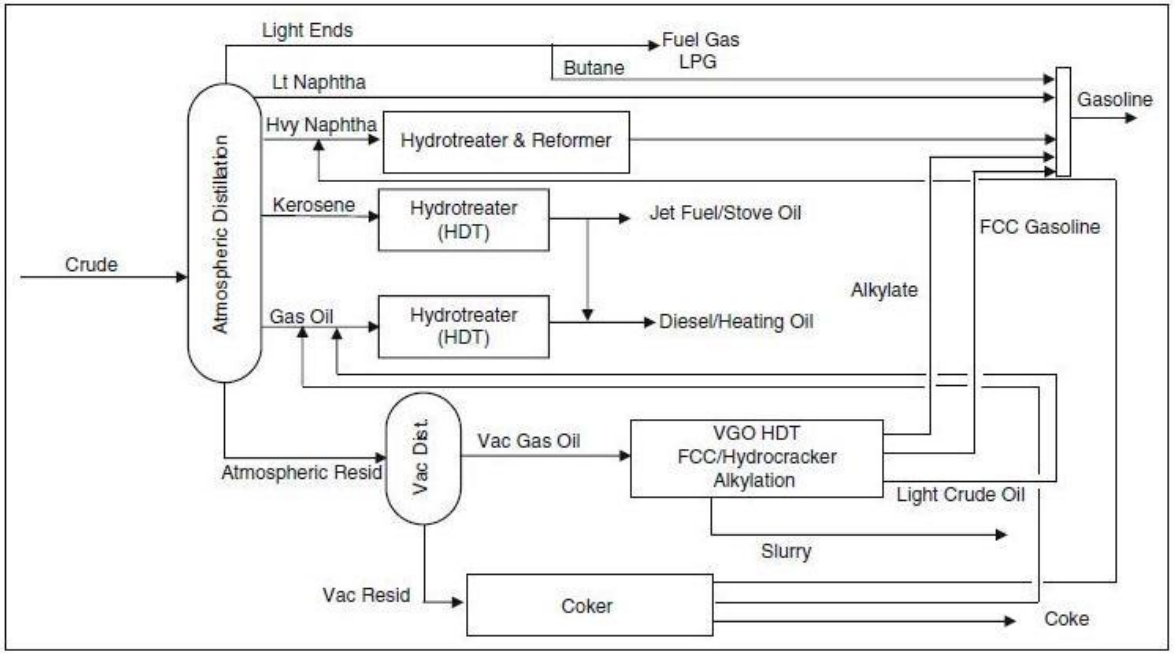


Figure 3. A high conversion cracking- coking refinery

Refinery Configuration. Refinery-petrochemical Integration

- the growth of the petrochemical industry has put pressure on refineries to either change their configuration or operating conditions to produce more aromatics and gases
- FCC has been developed to petro-FCC which produces high yield of gases
- the phasing out of the idea of increasing the octane number by increasing aromatic content has changed the role of the catalytic reformer to produce a high yield of aromatics as BTX feedstock

Refinery Configuration. Development of New Technology

- if a new technology is developed to give better yields, save energy, meet environmental regulations and product specifications, then this technology might replace old technology in existing and new refineries, depending on the economics.

Other **factors**, which might influence the refinery configuration, are

- feedstock availability
- product markets
- company's strategic objectives.