Introduction

The petroleum and his derivative become an important thing in our dilly life, it integrate the most estate of the new life, to be used as energy resource and oil derivative, the oil took several million yours to building up, different steps and technical to extraction and handling, in this chapter we will see the different steps flow the oil from the building up till the using in the daily life.

1- Crude oil building up:

It took several million years to oil deposits to get built up following a natural process. All deposits do not contain the same oil. Characteristics of deposits, and of oil contained, condition valorization methods of the resource.

1-1 Crude oil origin: kerogen

Crude oil comes from the decomposition of vegetal and marine organisms accumulated under the earth surface.

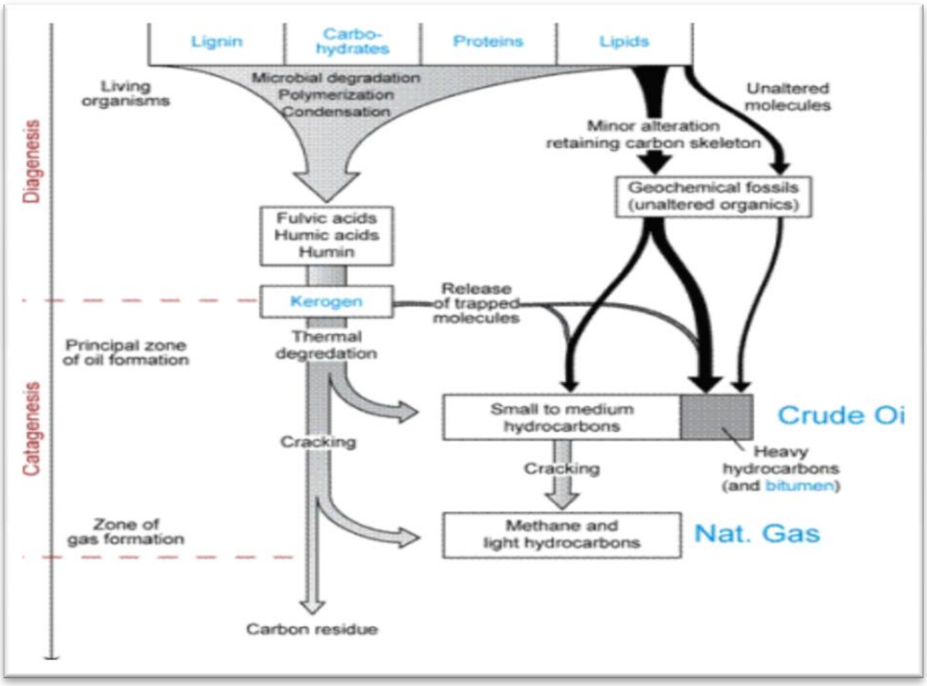


Figure 1 :formation of the oil

Several million years ago, wastes of numerous marine organisms deposited in deep oceans. With time, they accumulated and mixed to sludge and silt to form layers of sediments rich in organic matter : kerogen. Kerogen comes from the decomposition of organic matters by bacteria. Kerogen is disseminated in a mineral mass (parent rock) as small nets.

Sediments sink slowly into the ground, under the effect of plate tectonics, its own weight, and gravity.

Under the compressive effect due to high depths, these sediment layers transformed themselves into rock. With thickness increase of these sediment layers and of geothermic heat supplies, the temperature became higher and involved in a decomposition of organic matters into more simple substances : hydrocarbons. This thermal decomposition is called pyrolysis. Crude oil was then born.

1-2 Oil deposit building up:

Relatively light, crude oil naturally tends to go upwards to the earth surface. It migrates slowly through porous geological layers. When it meets impermeable rocks, an accumulation builds up (hence the origin appellation of petrol “petra oleum”, rock oil).

In oil cavities then constituted, natural gas (lighter) accumulates in the higher part, the crude oil lying down. Rocks of lower parts of a deposit are filled with water.

As you know, the most important oil deposits are located essentially in the Persian Gulf. Other important deposits are found deep sea. These are more dispersed.

On the other hand, we distinguish three great families of crude oil, according to their chemical composition:

- Paraffin predominance crude oils
- Naphta predominance crude oils
- Aromatic predominance crude oils

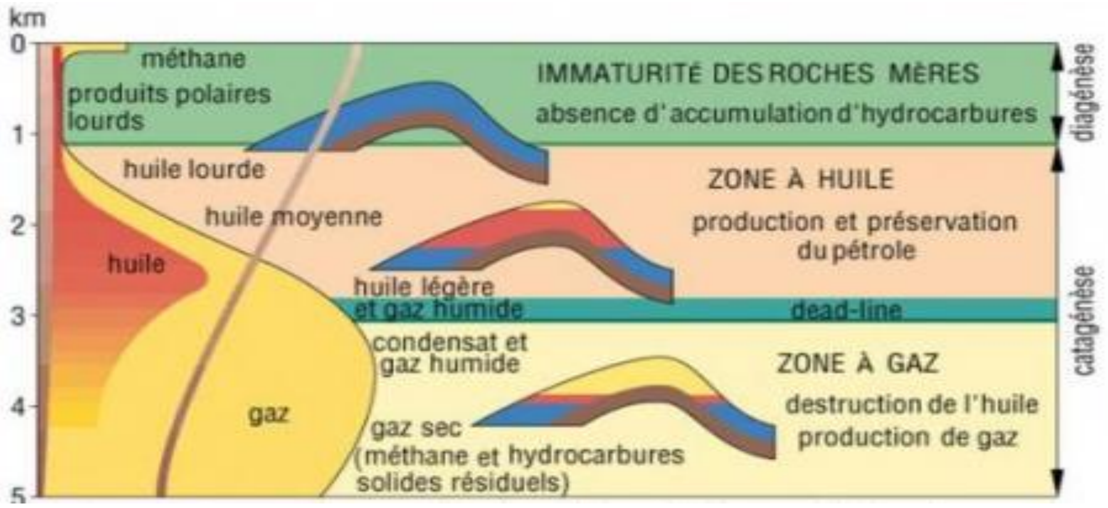


Figure2: Other kinds of crude oils, heavier, are suitable for making bitumen.

The lighter a crude oil is, the more suitable it for supplying a wide range of quality derivative products.

Characteristics and compositions of a crude oil condition its selling price.

2- Oil Traps :

Most oil and gas deposits are found in sandstones and coarse-grained limestones. A piece of sandstone or limestone is very much like a hard sponge, full of holes, but not compressible. These holes, or pores, can contain water or oil or gas, and the rock will be saturated with one of the three. The holes are much tinier than sponge holes, but they are still holes, and they are called *porosity*.

* The Two Types of Traps

a) Structural Traps

These traps hold oil and gas because the earth has been bent and deformed in some way. The trap may be a simple dome (or big bump), just a "crease" in the rocks, or it may be a more complex fault

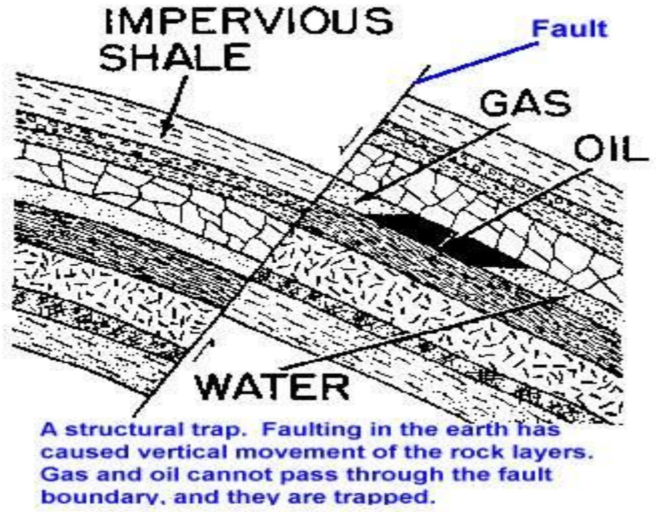


Figure3: draw explaining structural trap

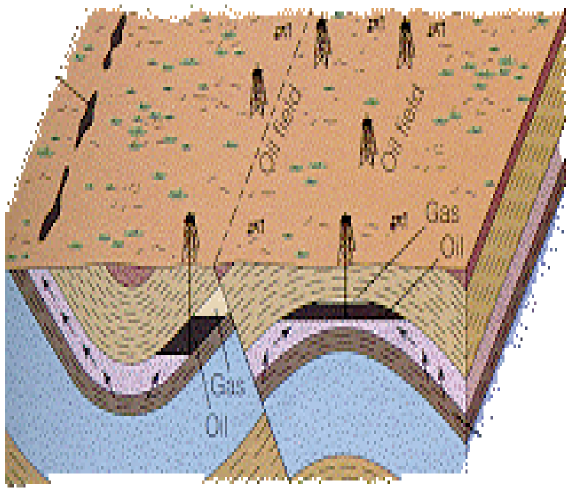


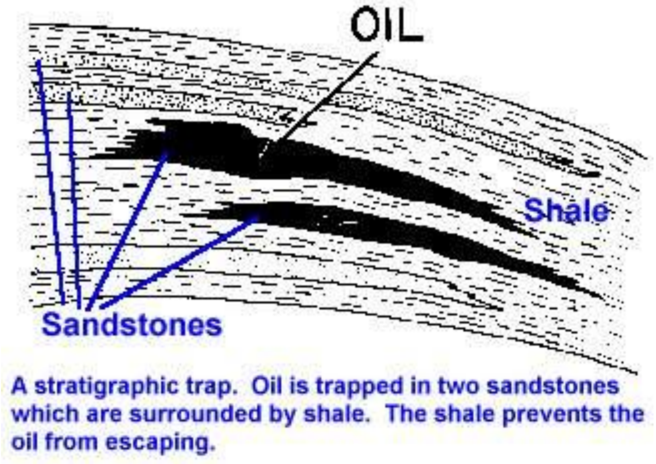
figure 4: design of structural trap

trap like the one shown at the right. All pore spaces in the rocks are filled with fluid, either water, gas, or oil. Gas, being the lightest, moves to the top. Oil locates right beneath the gas, and water stays lower.

Once the oil and gas reach an impenetrable layer, a layer that is very dense or non-permeable, the movement stops. The impenetrable layer is called a "cap rock."

b) Stratigraphic Traps

Stratigraphic traps are depositional in nature. This means they are formed in place, often by a body of porous sandstone or limestone becoming enclosed in shale. The shale keeps the oil and gas from escaping the trap, as it is generally very difficult for fluids (either oil or gas) to migrate through shales. In essence, this kind of stratigraphic trap is surrounded by "cap rock."



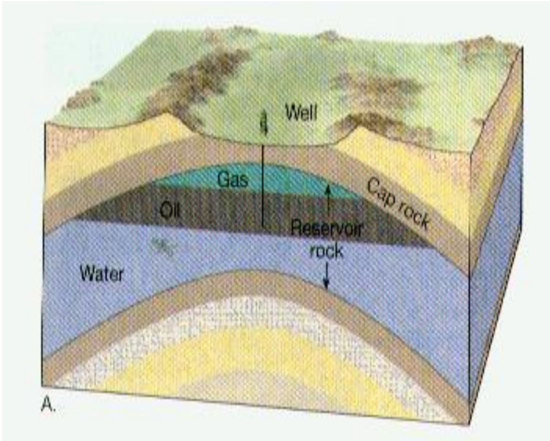


Figure 5: : explaining drawing of stratigraphic trap

figure 6: design ofstratigraphic trap

Here are four traps. The *anticline* is a structural type of trap, as is the *fault trap* and the *salt dome trap.*

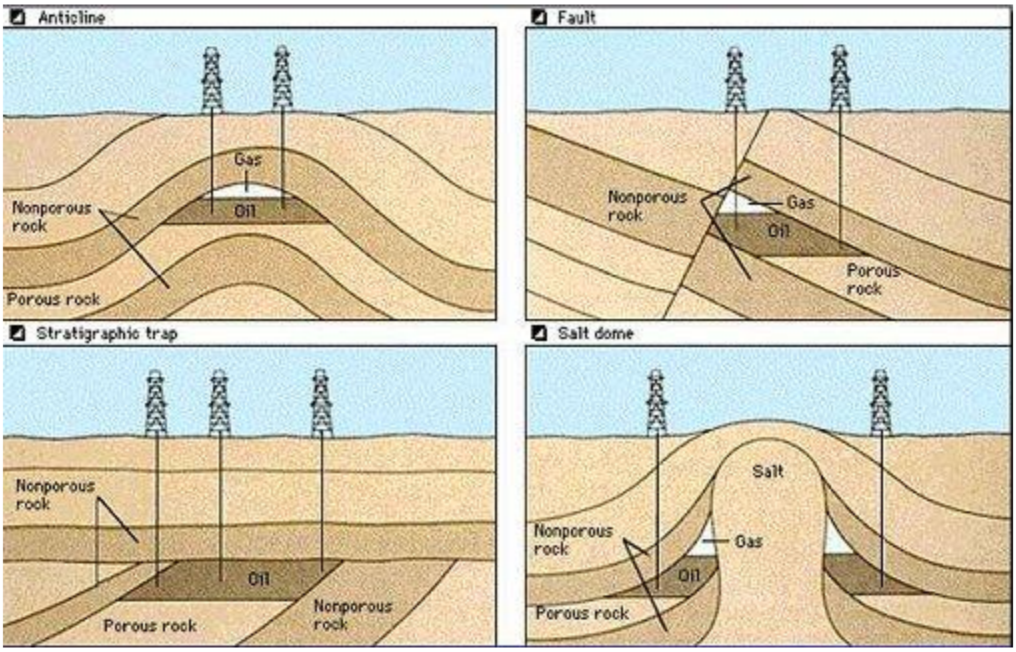


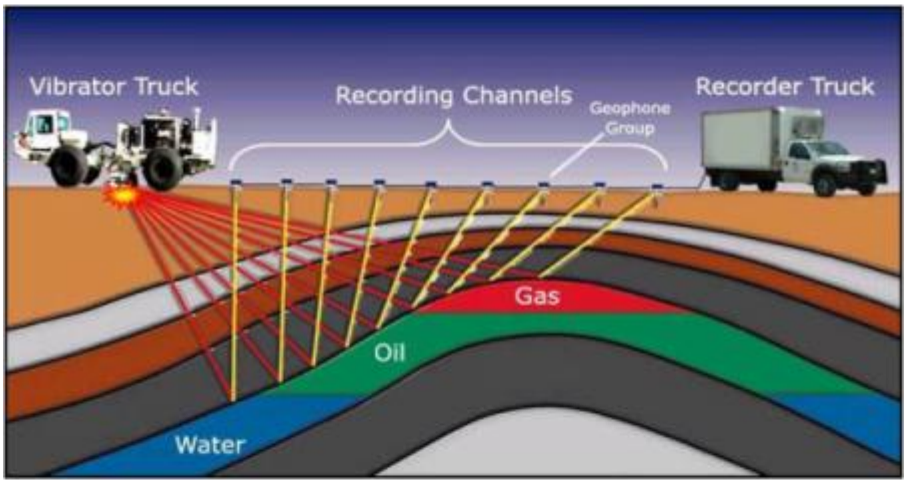
Figure 7: Four Types of Structural and Stratigraphic Traps

3- Crude oil extraction techniques:

3-1- Exploration and prospection of new crude oil deposits:

To find out crude oil, we research sedimentary basins in which some gas and oil may have formed. Gas and oil may have then migrated towards porous rocks able to contain big quantities.

Modern techniques of detection (satellite imagery, geophysical studies, seismic studies (tridimensional), even though onshore as offshore).



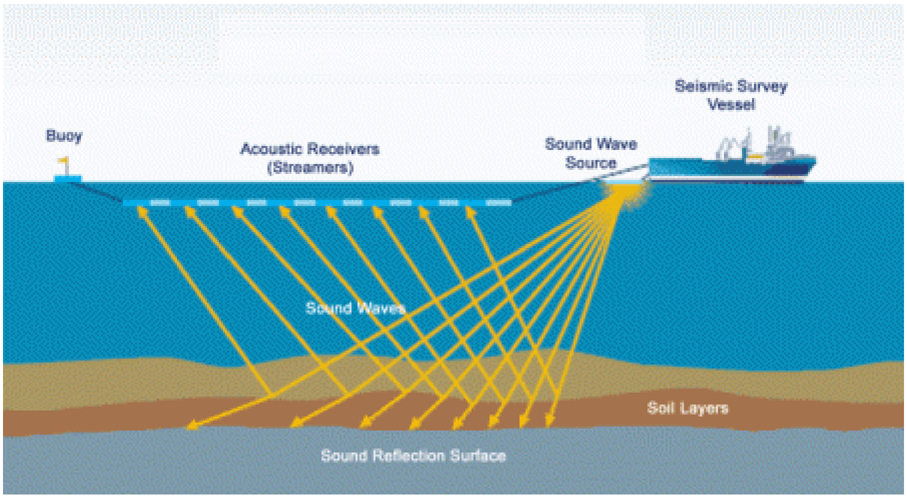


Figure 8: onshore and offshore exploration technical

3-2 Drilling of crude oil deposits:

After drilling an exploration well, intended for confirming oil presence, other wells are drilled to locate the deposit. Most wells are drilled with an auger, a cutting tool located at the extremity of a drilling stem pipe supported by a metallic tower called derrick. The auger is driven in rotation. The drilling speed varies highly according to the nature of rocks crossed. “Drilling sludge” (a blend of clay, water and chemical products) is injected permanently to the internal part of stems. It goes up to the space included between stems and well walls.

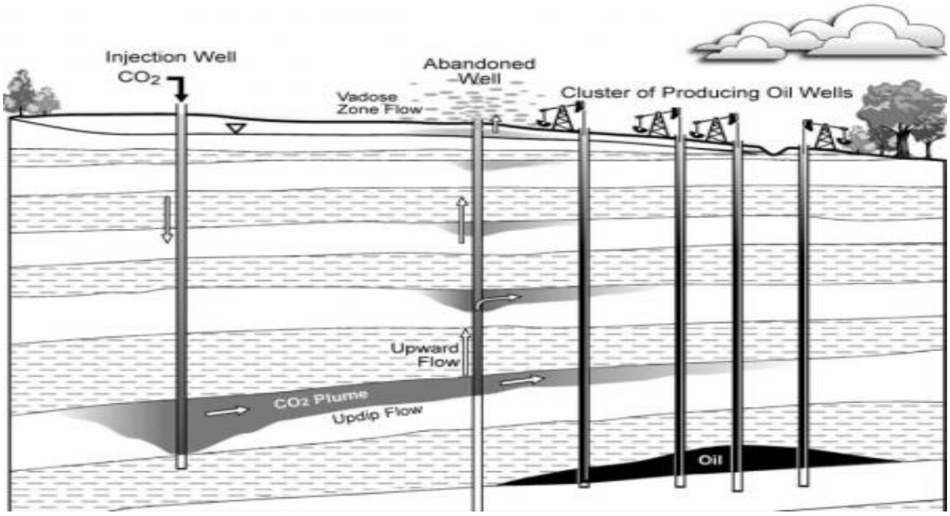


Figure 9: types of onshore oil well

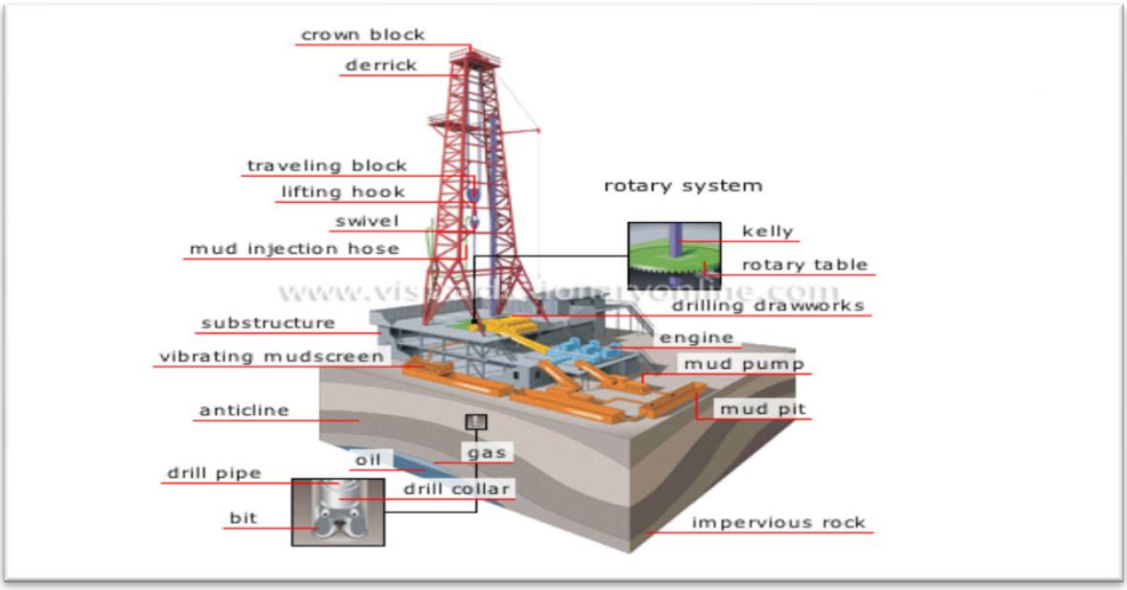


Figure 10: onshore drilling equipments

Sludge allows to cool down the auger and to evacuate drilling wastes. Back onto surface, sludge is filtered and re-injected into the well. The waste analysis allows to determine rocks crossed.

Progresses in drilling techniques allow now to make small diameter drillings, oblique drillings, horizontal drillings, multi-drains, and so on. These progresses allowed to exploit wells which were not profitable up to now, for technical and/or economical reasons.

Concerning offshore wells, we generally appeal for autonomous pumping platforms. Special ships may be used to exploit lower capacity deposits.

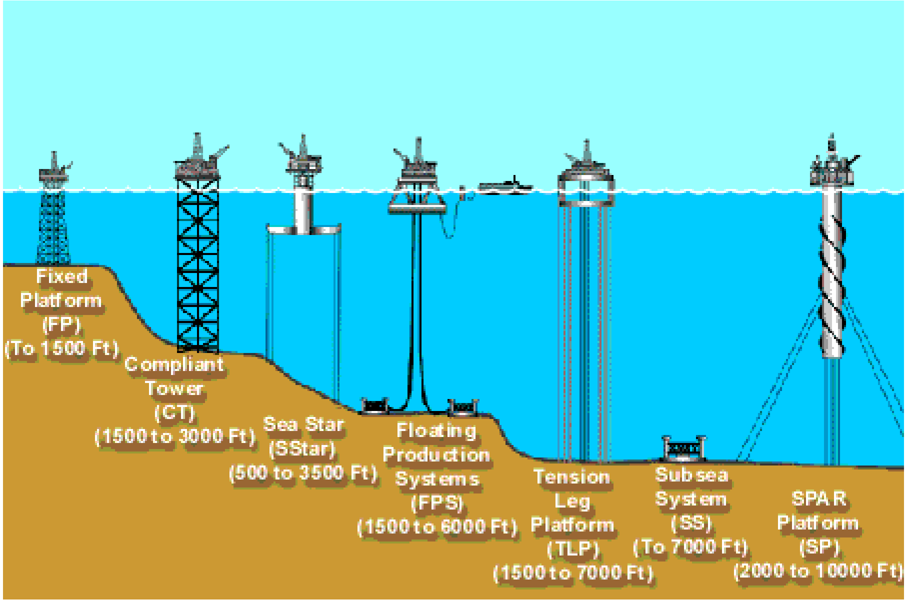


Figure 11: offshore drilling equipment types

3-3 Oil recovery:

According to the characteristics of the deposit, oil recovery may be carried out in a totally natural way or, on the contrary, it has to be enhanced.

a) Natural oil recovery:

If deposit pressure is sufficient, oil flows naturally, such as an artesian well. However, we often use the installation of rocking beam pumps. After extracting 20-30 % oil present in the deposit, it is necessary to proceed to an enhanced recovery. However, at present, we do not discover such kinds of deposits.

b) Enhanced oil recovery:

The evolution of technology now allows to move further most previous technical limits.

When deposit pressure is not sufficient, we proceed to a fluid(s) injection to oblige oil to come up to the surface. These fluids may be gas (that of the deposit, or liquefied petrol gas) or then water.

More evolved techniques (requiring more energy), such as thermal methods or driving by miscible fluid, allow to exploit difficult deposits.

Thermal method consists in heating oil to liquefy it (i.e. to reduce its viscosity). Heat comes from steam injection or underwater combustion.

Miscible fluid driving is carried out with CO_2 or liquefied petrol gas (lighter).

At last, chemical methods are used to try to limit the capillarity which retains oil in rocks. For that, we use polymers or oil, water, alcohols and surfactant agents based micro-emulsions.

3-4 Impact of technology evolution:

Technological progresses allow:

- To identify new oil deposits
- To exploit new deposits, where former technologies reached their limits
- To increase exploitation outputs (more exploited deposits, reduced cost price, and so on).

We can say that technology contributed to the increase in oil demand.

4- Crude oil handling

Before being an energy source to be used efficiently, crude oil has to be handled by various physical and chemical treatments. At the end of refining process, various derivative products are usable and used as fuels or basic substances for petrochemicals.

4-1 Distillation:

Crude oil is first heated at 370°C.

Then it vaporizes partially and is led to a fractionating column (a kind of distillation tower).

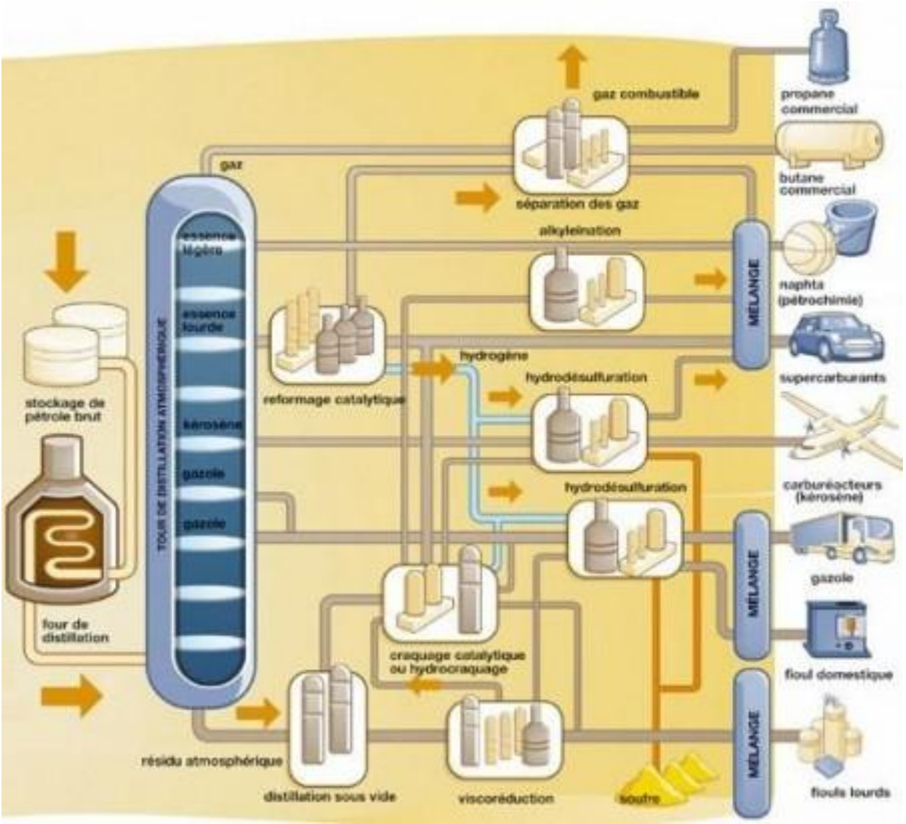


Figure 12: explaining drawing of distillation cercal

Up the column, refining gas used on the spot as fuel is collected. Other oil gas, such as butane and propane, fuels and naphta are also recovered. This latter is the base compound of petrochemical industry. Then kerosene is recovered (used in aviation, in jet engines), diesel and heating fuel. Lower down the column, wastes are recovered. These wastes are re-distillated under vacuum to get heavy fuels, lubricants and bitumen.

In order to obtain specific gasoline qualities (high octane index) and to reduce the sulphur content of diesels, products issued from distillation have to be handled again.

4-2 Cracking and reforming:

Cracking consists in fractionating long hydrocarbons molecules into smaller molecules. This operation may be carried out by thermal process under high pressures, or by catalytic process (under high temperatures and in presence of a compound facilitating the chemical reaction). When hydrogen is concerned, we speak about hydrocracking. When water is concerned, we speak about steam cracking.

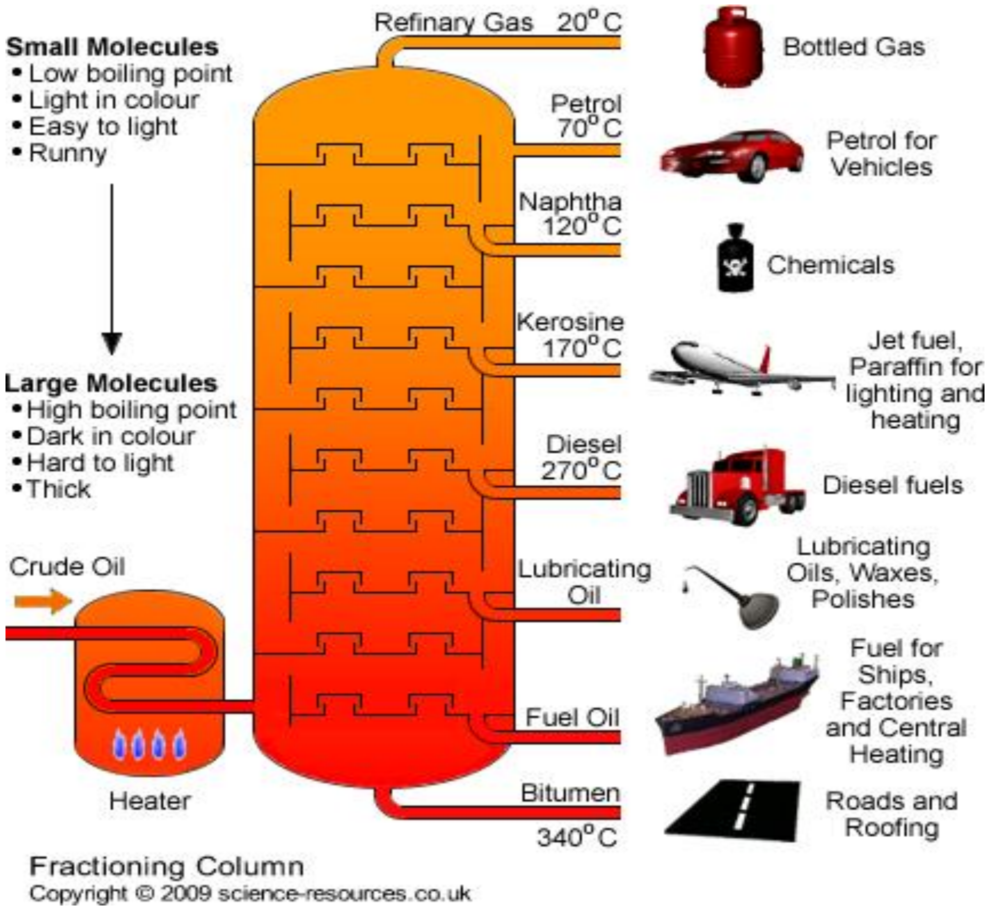


Figure 13:Cracking and reforming cercal

Reforming allows to convert naphta or to produce higher quality gasolines.

There exist other refining processes as isomerisation, alkylation and so on. We can then act on the characteristics of products obtained (octane index, color, odor, volatility …).

4-3 Conclusion of oil handling:

Oil has to suffer several handlings to be exploitable in the frame of a particular use. These multiple handlings concern energy consumptions. At the end, the numerous derivative products will be used in different ways (combustible, fuel, petrochemicals, plastics and so on).

Sometimes, these by-products are directly recoverable (gasolines, diesels and so on), and sometimes they will have to suffer other handlings to be exploitable, some of them are fatal products, without real outlets.

As the tendency is to recover a maximum of by-products, and as the proportion of derivative products obtained is relatively fixed, oil companies must then search for complementary outlets for derivative products produced in excess. For example, dieselization of the French fleet of vehicles impedes quantities of derivative products for which we have either to ensure demand or find new outlets.

5- Crude oil derivatives :

Crude oil has numerous derivative products in energy and chemistry areas. Gasoline and diesel represent the main oil derivatives. They are essentially used as vehicle fuel, but these are not the unique energy derivatives.

Other derivatives as liquefied petroleum gas (butane, propane and so on) or fuel oil are used as heating fuels or as power fuels.

Other derivatives are used in specific domains, such as chemistry.

5-1 Energy use oil derivatives:

Energy use oil derivatives are used as power fuels :

- Heavy fuel oil used for ship propulsion and some electricity production power stations
- Heating gas oil, used to agricultural tractors, ship propulsion, power generating sets
- Gasoline used in vehicles and small navigation and in some small power generating sets
- Diesel used in vehicle and road transport
- Kerosene used in aviation for jet engines
- Liquefied Petroleum Gas (LPG – butane, propane) used in vehicles.

Some of them are also used as combustibles in heaters, furnaces or for cooking:

- Heating fuel, for heating and hot water production
- Liquefied petroleum gas (LPG – butane, propane), for heating, hot water production and cooking.

5-2 Almost fixed production rates:

The problem:

Crude oil is valorized to its maximum.

Refining products, which cannot be sold, are upgraded internally in the refinery. The various processes, when refining, split up crude oil into different by–products intended for special uses.

Crude oil derivatives are produced in almost fixed proportions ; in any case, we do not dispose of a wide variation range of these proportions.

So, crude oil allows to produce approx 45.6 % gasoline, 20.9 % diesel and heating fuel oil, 9.4 % kerosene, 1.3 % naphta combustibles, 6.8 % oilseeds residues, 1.2 % lubricating greases, 3 % petrochemical raw materials, 3.2 % bitumen, 3.9 % oil coke and 3.6 % liquid gas.

The previous figures are an average for the United States. They vary from a country or refinery to another for multiple reasons (quality of crude oil used, consumption profile of local market, production flexibility of refinery plants, time of the year, and so on).

The capacity of refineries to modulate the proportion of derivatives issued from crude oil is low.

This narrow operation margin has an important consequence : to reply to a high demand increase of one of the derivatives, we have to succeed in marketing the overproduction of the other derivatives. This obliges oil companies to work together with the different industries, i.e. vehicle. This also means that alternative combustibles such as liquefied petrol gas will never be able to represent a significant proportion of the market.

6- Hydrocarbons classification:

6-1 By origin:

There are various crude oil origins. Most famous are:

- WTI (West Texas Intermediate – Texan crude oil)
- Brent (North Sea crude oil)
- Arabian Light (Persian Gulf light crude oil).

6-2 Liquid hydrocarbons classification

- “Crude oil” designates oil issued from a natural oil field exploited as a liquid at the atmospheric pressure. This designation means then a natural product before refining but having already lost a part of its field composition, as the light fraction of hydrocarbons leaves the liquid phase on the even place of its exploitation.

We talk about “Conventional crude oil” to be more restrictive, emphasizing on the exclusion of the following categories. ASPO (Association for the Study of Peak of Oil and gas) defined an even more restrictive category, the so-called “regular” crude oil, adding a classification by origin, excluding deep offshore (over 500 meters water) and the regions located over polar circles but including condensates.

- “Condensates”, also called “pentane plus” or C5+, or “liquids from natural gas wells” : this name designates the light fraction going from pentane (C_5H_{12}) to heptane (C_7H_{16}) or octane (C_8H_{18}). Condensates designate the hydrocarbons fraction which, as gas solution in the well, condensate as liquid at atmospheric pressure. They are generally associated with big natural gas wells but also with associated gas of oil fields.

They contribute largely to world supplies, amounting to 6 Mbep/d, and moreover it concerns very high quality liquids (light and low sulphur content).

It is rare that quantities concerning condensates are given expressly, they are almost ever included in crude oil, except for OPEC countries because they are excluded from quotas. Sometimes, condensates produced by exploited crude oil wells are included, but those produced by gas wells are calculated apart (this is the case in the United States for example).

- “Natural gas liquids” (ethane, propane, butane – C2 to C4) remain room temperature gas but are liquefied in plants handling gas by cryogenics. We talk about “plant liquid of natural”.

Butane and propane are often called Liquid Petroleum Gas (LPG) but, in this designation, there is no distinction between those coming from natural gas plants and those coming from oil refining (which also contains butane and propane in solution).

- Extra heavy crude oils, too viscous to be directly sold (not transportable by pipelines) may be launched on the market as per two methods :

- Syncrude (synthetic crude oil) is produced with it. This type of production is found in Canada (Athabasca : 600 kb/d approx – it concerns naturally solid bitumen) and in Venezuela (Orinoco Valley : over 550 kb/d – naturally liquid).

It is produced via onerous operations, mainly if it concerns bitumen, i.e. the hydrogen addition and steam and/or solvents injection to liquefy it in situ.

Extra heavy crude oil (from these two regions) sold not transformed into syncrude (then low valuated). It is either blended with light hydrocarbons (condensates, light crude oil, syncrude or naphta) to give a sufficiently fluid blend for pipeline transport, or as water emulsion (Venezuela Orimulsion).

At present, only Athabasca and Orinoco Valley produce extra heavy crude oils, but reserves exist (far smaller) in other places : Madagascar, Russia, Alaska, India, and so on.

Synthetic liquids produced from coal and natural gas. South Africa is from far the first producer (165 kb/d) and uses essentially coal as a raw material. Numerous projects are being studied in various countries (Qatar, China, and so on).

6-3 Agro-fuels, bio-diesel and alcohol type

- “Refining benefit” : refineries, thanks to hydrocracking (hydrogen addition) produce liquids globally a little less dense than the crude oil they purchase, so there is a volume benefit that we have to consider as a production category if we want that production and consumption figures coincide. It is a bit misleading, as obviously refining benefit is not an energy source. It is an usual effect to measure crude oil as a volume, whilst it would be more rigorous to measure it as a mass, or better as caloric power (apparently, this is practiced in New Zealand only).

These multiple categories make difficult the production and reserves valuation because numerous data sources give quantities without stating clearly what categories are taken into account or not. It is often difficult to compare two countries, even being sure to have figures including exactly the same thing. Furthermore, limits between categories are not clear sometimes. So, generally, we consider that the limit between bitumen and conventional crude oil is at 15° API (American Petroleum Institute), but this value is arbitrary. For Venezuela, the limit is at 10° API. A part of the quantities announced has then to be transferred to the non conventional crude oils category.

6-4 By quality:

Often, we talk about “conventional” crude oil/”non conventional “crude oil, but this distinction is subject to interpretation. Often, the “conventional” crude oil designates categories 1, 2 and 6, and sometimes only the category 1. Moreover, some classify as “non conventional” some crudes oils having high production costs, coming from deep offshore wells (and here again the limit is variable : 300, 500 or 1 000 water meters), from polar regions (Barents Sea and Alaska among others) or from mature wells in a tertiary recovery phase (for example by CO_2 injection).

Crude oils, though they are conventional crude oils, condensates or syncrude, do not have all the same quality. Different ranges allow to compare crude oils between them. The most important ones are density and sulphur content.

- "API density" (conceived by American Petroleum Institute) is used in the Anglo Saxon system to express crude oil density. A liquid, the API degree of which is 10° API, at a temperature amounting to 15° C, has a density equal to 1.00 (i.e. that of water, 1 kg/liter) at the same temperature. A density equal to 22° API at 15° C is equivalent to 0.9218 density at 15° C, and 35° API at 15° C is equivalent to 0.8498 density at 15° C. The lower limit of conventional crude oil is generally placed at 15° API.

Generally, we talk about heavy crude oil less than 20° API, medium crude oil 20-30°API and light crude oil beyond this figures, but these boundaries vary according to the countries. The lightest crude oils are most required by refiners because they give directly numerous light layouts with high value (diesel oil, gasoline, naphta). Conversely, heavy crude oils give more products, such as bitumen and residual fuel, that have either to be sold as they are at low price, or to be converted into lighter layouts, particularly by hydrocracking (hydrogen addition).

- The sulfur content varies considerably from a well to another, so from a commercial blend to another, from 0.03 % to 5 % approx. Sulphur is a polluting agent that refiners have to extract (at least in countries having laws against acid rains). Then, it reduces the crude oil value. Generally, the limit between "sweet" crude oil and "sour" crude oil is 1.5 % sulphur.

A crude oil may be:

-VLSC (Very Low Sulphur Content)
-LSC (Low Sulphur Content)
-MSC (Medium Sulphur Content)
-HSC (High Sulphur Content)
-VHSC (Very High Sulphur Content)

Apart from these two main ranges, there are numerous other quality criteria, i.e. viscosity, acidity, ratios between types of hydrocarbons (cyclical or not, saturated or not) and nitrogen contents, heavy metals contents, salts contents, and so on.

The crude oil price depends, in major part, on its chemical and physical characteristics. So, a crude oil HSC (High Sulphur Content) has a lower price than a crude oil LSC (Low Sulphur Content), a naphtenic crude oil is more onerous because this crude oil, after reforming, will give a lot of aromatic products with high octane index, serving as a basis to produce regular gas and premium gas. If kerosene fraction of crude oil is abundant and if its freezing point is very low, for example -54° C, this crude oil is more onerous because kerosene acts as a basis in the production of Jet A1, fuel for planes.

The price of a given crude oil is then fixed according to the initial well and to their containers, but also to crudes oils serving as a reference (Brent, WTI, Arabian Light, Minas, and so on). A given crude oil, according to its quality and to its markets distance (to reflect the transport cost, which sometimes reaches 4 €/bushel), gets a price differential compared to the reference crude oil. This differential is most often negative, as crude oils acting as a reference are high quality crude oils and available near consumption places. And also, it varies according to the market.

7- Crude oil transport and storage:

Due to its energy density and its liquid form, oil is relatively easy to store and to transport on long distances.

7-1 Oil transport:

a) Ship transport on oil tankers:

Oil shipping on oil tankers and super tankers, able to carry up to 400 000 tons crude oil, represents over half world shipping commerce.

Figure 14: photo of oil shipping

Tankers are conceived as huge tanks, sometimes split up in several compartments, to store oils having different characteristics (for example, density). So, we can manage better mass repartition on the tanker.

Note that, on these last thirty years, numerous sea catastrophes concerning super tankers took place (Exxon Valdez, Amoco Cadiz, Erika, Prestige, Tasman Spirit, and so on). They caused ecological and economical catastrophes on coast reached by oil spill. Global costs for cleaning up and indemnifying were taken in charge by collectivities of local governments. Since, new oil transport tankers are equipped with double hulls, supposed to reduce these risks of catastrophes.

The titanic size of super tankers involves in huge fuel consumptions. They remain reasonable compared with their transport capacity. Presently, over 700 oil tankers having a tonnage over 200 000 tons are navigating.

b) Oil transport by oil pipelines:

The most simple and secure way to carry oil from a point to another is the pipeline. In these pipes, oil is sent at a speed of 5 km/hr. This speed is continuous due to pumping stations installed at regular intervals along the pipeline track.

Figure 15: photo of oil pipes transport

7-2 Oil storage:

Oil does not involve especially in storage problems thanks to its liquid state. It is then stored in tank or reservoir. Under its crude form, oil is generally viscous and leaks are limited. The transfer of a storage means to another is carried out by pumps. Some oil derivatives, as gasolines, are more volatile and necessitate more care, i.e. considering fire risks.

Figure 16: storage of oil

7-3 Conclusion on oil transport and storage:

The liquid state of oil makes transport and storage easy. Storage and transport do not present any complex technical problems. On the contrary, problems arise when transport and storage infrastructures fail.

Conclusion

The excessive exploitation of the petrol is arise, even the high cost of its production, human and material resource, the low of the international store, and development of new power resource, the oil stile keep his place as shorter way to answer the extreme demand of power.