P3 PETROCHEMICALS

FROM CRUDE OIL TO PETROL

CHEMICAL INDUSTRIES RESOURCE PACK

Introduction

All fossil fuels consist of a mixture of chemicals. Before these chemicals can be used effectively, they must be separated in a refinery. A refinery uses the traditional refining process of **fractional distillation.**

Fractional distillation: making petrol and diesel from crude oil

Crude oil is a mixture of many chemicals. Most chemicals are in the liquid phase; where solid and gaseous chemicals are present they are dissolved in the liquid phase. To separate the mixture of chemicals, scientists make use of the physical property of boiling point - each chemical has a unique and constant temperature at which it changes from a liquid into a gas. This temperature is determined largely by the molar mass of the chemical.

Crude oil is heated to about 400°C and injected into the bottom of a fractionating tower. The fractionating tower is a tall vertical column, sometimes up to 100 m in height.

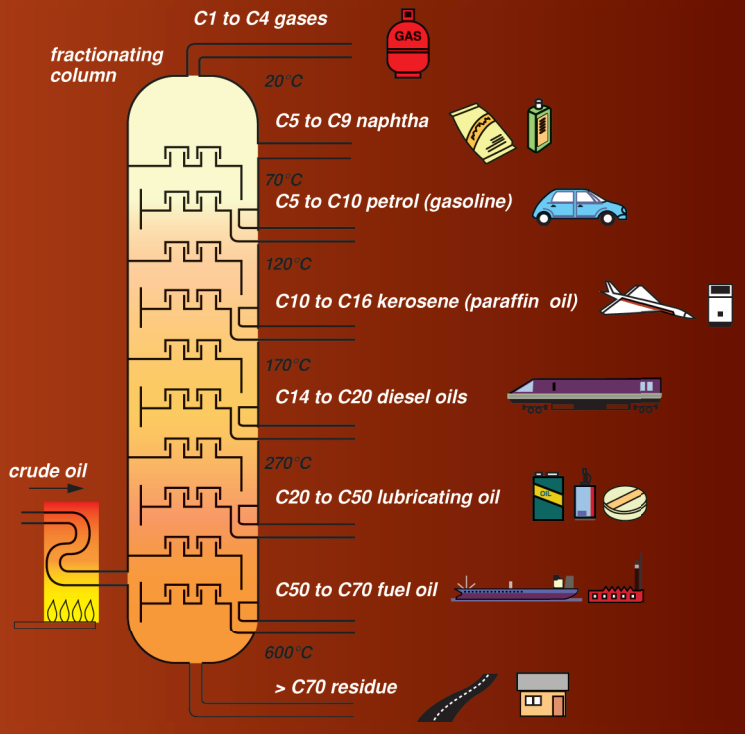
On the inside it contains many stainless steel collecting trays at various levels. There is a temperature gradient inside the column - the base of the column is hot and the temperature decreases slowly as the height above the base increases. The coolest part is at the top of the column. At the base most of the oil boils and the vapour rises up the column.

As the vapour moves up the tower, the temperature decreases, and when the condensation point of a certain fraction of chemicals is reached, that fraction condenses in a tray and is removed from the vapour. The rest of the oil, which is still in vapour form, rises up to the next level where the next fraction condenses, and so on. The many levels of the fractionating tower separate the oil into many fractions. The smallest molecules with the lowest boiling points are collected at the top of the tower. The wax and tar that do not evaporate are collected from the base of the tower. This separation of crude oil into separate fractions by using their boiling points is called fractional distillation.

A fractional distillation column is designed to separate the crude oil into the following fractions according to the diagram below.

A fractionating tower

Source: www.energybulletin.net



Fraction	# of C atoms	Boiling Range (°C)	Uses
Gas	1 - 4	-162 - 30	Fuel gas; starting material for plastics manufacture
Petroleum ether	5 - 6	30 - 60	Solvents, petrol additives
Petrol (gasoline)	5 - 12	40 - 200	Petrol
Kerosene	11 - 16	175 - 275	Diesel fuel; jet fuel; heating oil
Heating oil	15 - 18	275 - 375	Industrial heating
Lubricating oil	17 - 24	> 350	Lubricants
Paraffin	20 and up	Solid residue	Candles; toiletries; wax paper
Asphalt	30 and up	Solid residue	Road surfacing

Everyday products that make use of these molecules

Further refining of fractions

The fractions received from fractional distillation are then treated to separate the chemicals further. These processes include vacuum distillation to separate lubricating oils and waxes from the residue, desulfurisation to remove sulfur and cracking to produce more petrol and alkenes.

Catalytic cracking

The demand for naphtha and petrol exceeds the amount of this fraction received from primary distillation, so higher boiling fractions containing larger molecules are broken down to produce more petrol and naphtha. This process is called catalytic cracking. The fraction of high molecular mass alkanes is mixed with a catalyst (typically Co or Pt) in a reactor at a temperature of about 500°C. The smaller alkanes and alkenes that form can be separated by distillation. For example, decane ($C_{10}H_{22}$) is vapourised and passed through a bed of catalyst powder.

The decane molecules split apart, or crack, on the surface of the catalyst. One possible reaction that can occur is:

$CH_3(CH_2)_8CH_3 \rightarrow CH_2{=}CH_2 + CH_3(CH_2)_6CH_3$

decane → ethene (ethylene) + octane

Ethene (also known as ethylene) can be used to make polyethylene (PE). Octane is part of the petrol fraction and therefore used in fuel for cars.

Petrol blending

Petrol is a mixture of about 300 different hydrocarbons and other additives. The hydrocarbon fractions must be blended (mixed) to deliver a product with the same specifications every time. In colder climates different petrol blends are made for summer and winter.