background sheet

How is crude oil processed?

The distillation process

Crude oil is a mixture of hydrocarbon molecules. Because the molecules range in length and configuration they exhibit different properties, such as boiling point. Fractional distillation is a process used in the purification of crude oil.

This process separates crude oil into different fractions based on the boiling point of component molecules. The fractions, from highest to lowest boiling point, consist of heavy gas oil, lubricating oil, gas oil and diesel, kerosene, gasoline, naphtha and gas.

Once separated, fractions can be further treated to produce a multitude of materials used everyday, including fuels, plastics and medicines.

Steps in the fractionation process are as follows:

- Crude oil is heated in a furnace to almost 600 °C. Most substances within crude oil will boil at this point and vaporise.
- The heated gas/liquid oil mixture is fed into the lower section of a distillation column. Substances that remain in their liquid state sink to the bottom of the column and are pumped out. This sticky, black mixture is called residual oil.
- Hydrocarbons in their vapour state rise up the column, passing through holes in distillation trays that line the inside of the column.
- As these gaseous hydrocarbons rise they begin to cool. Once they cool below their boiling point they condense into liquids on the nearest distillation tray.
- These trays collect liquid fractions that are drawn out of the column.

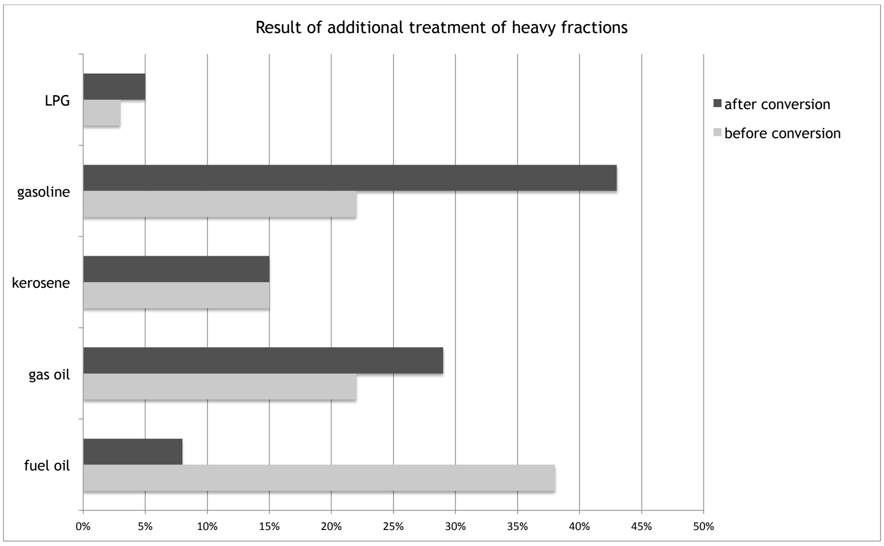
Economic influence

The refining process is driven by market demand. The purpose of refineries is to produce materials required by the market. The biggest demand across world markets at the moment is for fuel for motor vehicles. However, the petrol content from a normal distillation process is not sufficient to meet the high demands of consumers. Longer hydrocarbons recovered in the fractionation process can be broken down, and other fractions can undergo a reshaping or rebuilding process. Each time hydrocarbons require processing, energy is required.

As a further complication, crude oil from different places in the world has a different mix of heavy and light hydrocarbons. This means that crude oil may need more or less treatment, depending on where it comes from. Less treatment is required to produce materials like petrol if there are fewer heavy hydrocarbons. Crude oil that contains a high percentage of heavy hydrocarbons is usually cheaper because it requires more processing, which is expensive.

The percentage of gasoline (petrol) recovered from fractional distillation of crude oil can be increased by additional treatment of heavier fractions.

In this example, the percentage of gasoline is almost doubled through a cracking process that splits heavy hydrocarbons into the lighter fuels.



Processing

Cracking breaks down heavy, long hydrocarbon molecules from crude oil into lighter, shorter ones such as LPG and gasoline. There are three different processes that can be used: thermal cracking, hydrocracking or catalytic cracking.

THERMAL CRACKING	HYDROCRACKING	CATALYTIC CRACKING
Converts: residual oil to fuel oil, diesel, petrol and naphtha. *Process:* Intense heat is used to break down the heaviest hydrocarbon molecules that have emerged from the bottom of the distillation column. Thermal conversion, or coking, puts these residuals under intense heat and pressure to break down or 'crack', large hydrocarbon molecules into smaller molecules. These are vapourised out of the coker. The by-product of this process is almost pure carbon known as coke. It is a fuel used for coke furnaces.	*Converts*: gas oil to petrol. *Process*: This process is used on gas oils, kerosene and naphtha. They are heated to 300 - 400 °C at high pressure with hydrogen in the presence of a catalyst. Hydrocracking also assists removal of impurities such as sulfur, nitrogen and trace metals. Gases such as hydrogen sulphide are produced that can be removed easily.	*Converts*: Gas oil or residual oil to diesel and petrol. *Process*: Gas oil or residual oil can be broken down in the presence of a catalyst under intense heat and pressure conditions. Hydrocarbons react on contact with the catalytic surface to break down into smaller hydrocarbons. Sometimes hydrogen is also added to the process as hydrocarbons such as bitumen have a low hydrogen content. The end product of catalytic conversion is higher grade than that of thermal conversion alone, but the cost is significantly higher.

Molecules can also be rearranged to form new molecules through the processes of alkylation, isomerisation and reforming.

ALKYLATION/CATALYTIC POLYMERISATION	ISOMERISATION	REFORMING
Converts: propene and butene to high octane hydrocarbons *Process*: Molecules can be combined to form new products. This is often done in the presence of an acid catalyst.	*Converts*: pentanes and hexanes to high octane isomers *Process*: Converts straight-chain hydrocarbons to branched chains. This can improve the quality of hydrocarbons which will be blended into petrol.	*Converts*: naphtha to high-octane petrol and petrochemical feeds *Process*: Naphtha, which contains many branching and ring molecules (paraffins and naphthenes), can be reformed using pressure and catalysts. Reformation produces isoparaffins and aromatics that improve petrol quality.

Useful resources

- Freudenrich, Craig. (n.d.). *How oil refining works*. Retrieved February 6, 2008, from http://science.howstuffworks.com/oil-refining.htm
  'How stuff works' provides a concise, step-by-step view of the distillation process and the processing of fraction including diagrams and animations.
- Gerding, Mildred. (1986). *Fundamentals of Petroleum*. Austin, Texas: Petroleum Extension Service, University of Texas at Austin. ISBN 0-8869-122-0.
  Chapter seven provides a detailed look at refining and processing of crude oil. Its content and language are accessible to high school students.