Stefan Reeve

Keeping engines running smoothly

Modern car engines can run smoothly and propel you for thousands of miles without needing much attention, apart from refuelling with the diesel or petrol needed as a source of energy. The engine also needs oil. What is engine oil, how does it work and how can it be recycled or disposed of?

TopFoto

GCSE key words
Oil properties
Oil refining
Oil pollution
Fractional distillation

Oil is used as a lubricant in all internal combustion engines and in most machines with rotating parts. For the purpose of this article we are going to focus on car engine oil. Engine oil is a remarkable material – in modern car engines it can work as a lubricant without needing to be changed for thousands of miles. The purpose of engine oil is to minimise corrosion and wear by reducing friction, oil oxidation and deposit formation. A lot of sophisticated chemistry is required to do this.

What is engine oil made of?

Car engine oil is made up of petroleum base oil (80%) and a package of additives (20%). Petroleum base oil is made from the higher boiling point portions of crude oil, which remain after the lighter fractions have been removed (see Box 1). As crude oils are obtained from various parts of the world their chemical composition and properties can differ widely.

Box 1 Refining crude oil

Crude oil is refined by a continuous process called fractional distillation, which generates a variety of products (see Figure 1). This process divides the parts of crude oil by their boiling points.

The crude oil is heated and fed into the bottom of the distillation column. The gases rise up the column, passing through a number of 'bubble caps'. Here liquids with a high boiling point condense while those with a low boiling point continue further up the column, where they pass through further bubble caps.

In this way the mixture is separated into a number of different fractions. Those fractions at the top of the column have a low boiling point – and hence a low molecular mass – while those near the bottom have a high boiling point and high molecular mass. The part that is used to produce lubricants has a relatively high molecular mass.

Box 2 Useful websites

www.bp.com
www.shell.com
www.exxonmobil.com
www.environment-agency.gov.uk

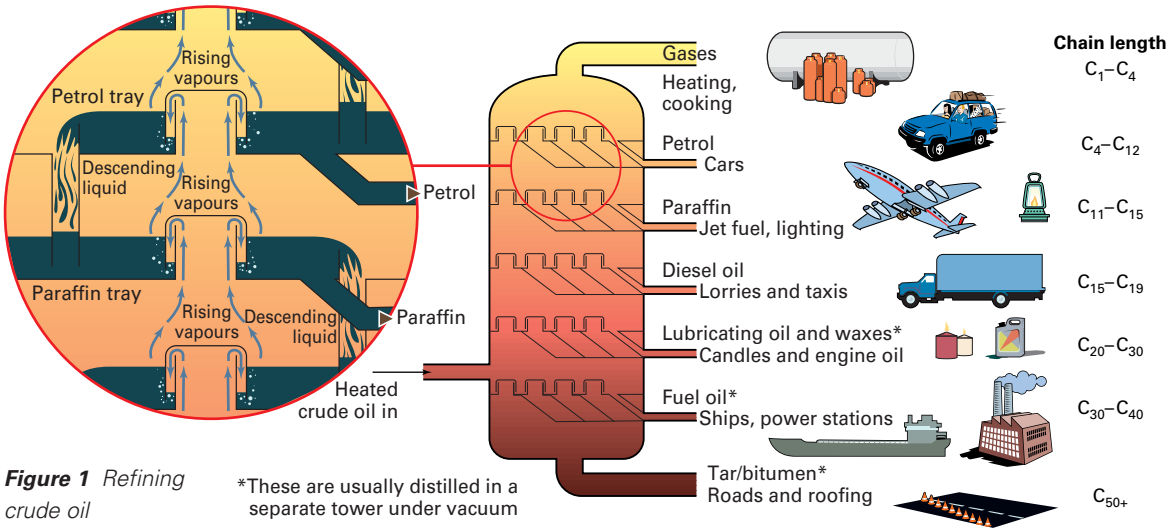

Figure 1 *Refining crude oil*

*These are usually distilled in a separate tower under vacuum

What is in the additive package?

This is where it gets interesting! The motor industry is extremely competitive — and not only in motor sport. Consumers have high expectations of performance and want value for money. Car manufacturers have to take into consideration all the factors that go into making their cars run well and efficiently for as long as possible. This means they choose and often recommend specific engine oils that have been developed to prolong the life and enhance the performance of their vehicles.

The additive package varies from oil to oil. The companies which produce the additive packages often keep their contents a closely guarded secret, but essentially they are made up of varying proportions of the following 11 components.

Detergents

These are surface active agents (similar to household detergents) which act to prevent deposit formation on engine parts. These deposits would form a 'lacquer' over the many parts of the engine, which in time would diminish performance.

Available in different strengths and degrees of 'over basing', detergents can both prevent deposits and clean up those that have already formed. The 'over basing' neutralises acidic impurities that accumulate in the engine oil over time, thus minimising engine corrosion and preventing a reduction in the oil's lubrication properties.

Dispersants

These molecules bond to the sooty contaminants in the oil that result from exhaust gas contamination and keep them from clumping together. The sooty contaminants are then kept suspended in the oil until they can be removed by a filter or oil change. Without dispersants, deposits would build up on the piston head and form a sticky mass, which could break loose and block ports and valves.

Anti wear/extreme pressure agents

These agents bond to the metal surfaces to create a strong lubricant film between the moving metal parts. This film can withstand extreme heat and mechanical pressure. It prevents the moving metal parts from coming into direct contact with each other, thus protecting them from scoring and seizing.

Friction modifiers

In effect, these make oil more slippery, thereby reducing the friction between moving parts. This both reduces wear and improves fuel efficiency.

Antioxidants

Even highly refined base oils contain some organic compounds that can decompose by oxidation (exposure to air) in the presence of heat. This destroys the oil's ability to lubricate and results in severe engine deposits. Antioxidants inhibit this process by 'locking up' the organic compounds.

Over time, acid will form in the oil. To pre-empt this, an alkaline 'base' is put into the oil to neutralise this acid as it develops. 'Over basing' is done to ensure that there is enough base present throughout the life of the oil.


Grangemouth refinery in Scotland

BP plc

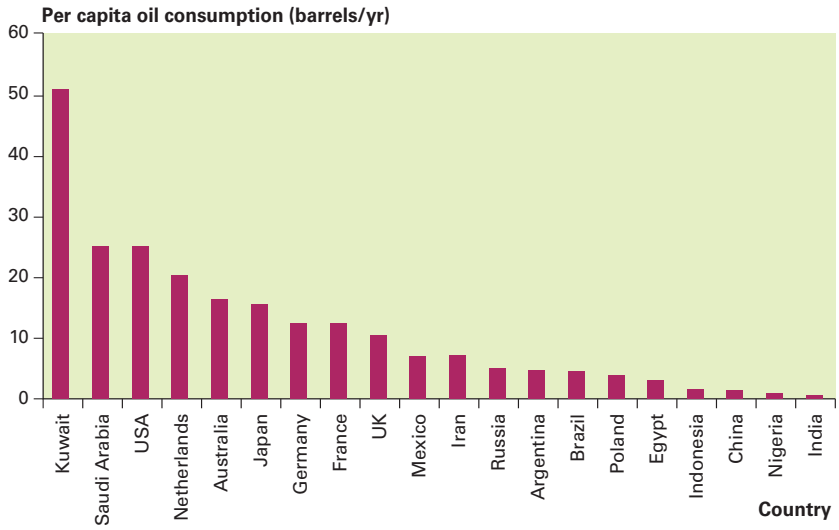

Figure 2 *International consumption of crude oil in 2001. This graph shows the amount of oil in barrels consumed per person per year by each country*

Right: *Engine oil is used to lubricate moving parts*

One barrel of oil weighs approximately 140 kg.

In the UK we consume an average of just over 10 barrels of oil per person per year.

'Cold cranking' is when you turn over the engine to start a car before it has warmed up or when the temperature is very low. Pour point depressants are very important in Canada and other countries which experience extreme cold for large parts of the year.

Rust/corrosion inhibitors

These prevent the corrosion and rusting of metal parts in contact with the lubricant. They work by neutralising the effects of water and acids formed as part of the combustion process.

Pour point depressants

Engine oils are effective at high temperatures in a running engine. When an engine is started from cold, oil still needs to flow freely to lubricate moving parts. Cold cranking is when the potential for engine wear is at its greatest. Pour point depressants allow the oil to flow better at lower temperatures as well.

Antifoam agents

These inhibit the formation of foam in oil that can result from the mechanical action of the engine and reduce the oil's ability to lubricate effectively. The antifoam agents reduce the surface tension of the fluid thus making it less likely to form foam.

Seal conditioners

Seal conditioners cause the engine's gaskets and seals to swell, creating a better join between the engine parts. This prevents fluid leakage.

Metal deactivators

These form an inactive film on metal surfaces that reduces the tendency of the metal to react with the oil in ways that increase the rate of oil oxidation.

Viscosity modifiers

Temperature affects viscosity grade, making oil either thicker or thinner. This lessens its ability to protect engine parts at temperature extremes. Viscosity modifiers are flow control agents that allow the oil structure to adapt to temperature changes, maintain its grade and retain its lubricating effectiveness. This is what makes multi-grade oils possible.

What happens to these oils after use?

Used engine oil poses a serious threat to the environment and wildlife if it is not disposed of properly. Just a few litres can form a thin film over a small lake! The oil industry is therefore under increasing pressure to find ways of recycling such materials so that they do not cause ecological harm.

There are two options for the reuse of waste oil:

- recovery of the petroleum base oil
- reuse as a fuel

Recovery of the petroleum base oil

If we choose to recover waste oil that has been drained from cars, then the water, dirt, heavy metals (such as magnesium, copper, zinc and others which are picked up from the engine), nitrogen, chlorine that is present in some dispersants, and oxygenated compounds all need to be removed through processing and refining.

At the end of these processes we are left with re-refined petroleum base oil. However, if this recovered base oil is to be reused it must meet the same standards as the original base stocks.

Reuse as a fuel

If we choose to reuse the waste oil as a fuel in industries such as power generation, the process is more straightforward, although water and particulates must first be removed.

The need for an alternative power source

It is worth noting that the recycling process itself is energy intensive and also produces waste and harmful pollutants, *so recycling is not always the most environmentally-friendly approach, even if it is still regarded as the ideal*.

Ultimately, an alternative power source is required if today's transportation systems are to become sustainable. However, in the meantime everyone can help to reduce environmental damage from used oils by following the Environment Agency's guidelines and disposing of their used engine oil at their local council's recycling centres.

Stefan Reeve *is a chemical engineer who works in the additive industry.*