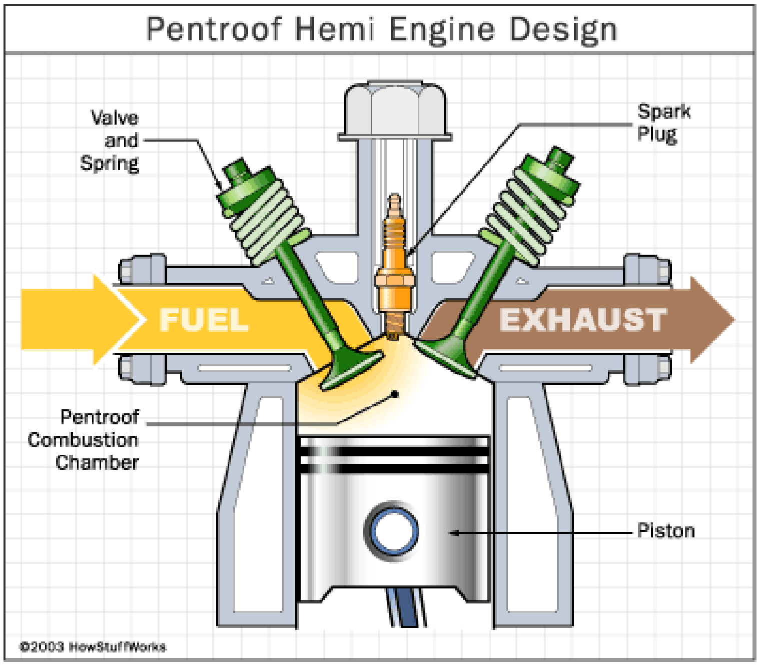
Tech Torque
HOW PETROL ENGINES WORK

The Basics

The purpose of a gasoline car engine is to convert gasoline into motion so that your car can move. Currently the easiest way to create motion from gasoline is to burn the gasoline inside an engine. Therefore, a car engine is an **internal combustion engine** -- combustion takes place internally. Two things to note:

- There are different kinds of internal combustion engines. Diesel engines are one form and gas turbine engines are another. Each has its own advantages and disadvantages.
- There is such a thing as an **external** combustion engine. A steam engine in old-fashioned trains and steam boats is the best example of an external combustion engine. The fuel (coal, wood, oil, whatever) in a steam engine burns outside the engine to create steam, and the steam creates motion inside the engine. Internal combustion is a lot more efficient (takes less fuel per Km) than external combustion, plus an internal combustion engine is a lot smaller than an equivalent external combustion engine. This explains why we don't see any cars from Ford and GM using steam engines.



Inside a typical car engine

Almost all cars today use a reciprocating internal combustion engine because this engine is:

- **Relatively efficient** (compared to an external combustion engine)
- **Relatively inexpensive** (compared to a gas turbine)
- **Relatively easy to refuel** (compared to an electric car)

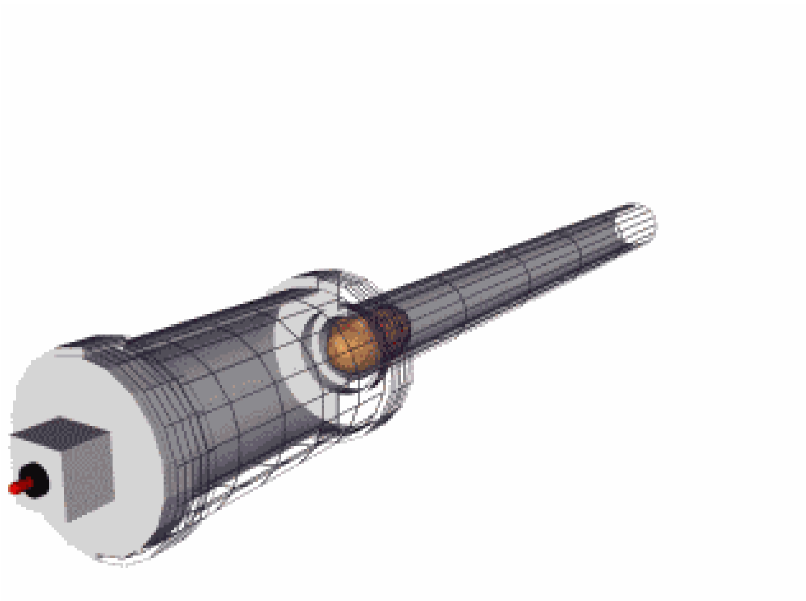
These advantages beat any other existing technology for moving a car around.

HOW PETROL ENGINES WORK

Combustion Is Key

To understand the basic idea behind how a reciprocating internal combustion engine works; it is helpful to have a good mental image of how "internal combustion" works. One good example is an old Revolutionary War cannon. You have probably seen these in movies, where the soldiers load the cannon with gun powder and a cannon ball and light it. That is internal combustion, but it is hard to imagine that having anything to do with engines.

A more relevant example might be this: Say that you took a big piece of plastic sewer pipe; maybe 3 inches in diameter and 3 feet long, and you put a cap on one end of it. Then say that you sprayed a little WD-40 into the pipe, or put in a tiny drop of gasoline. Then say that you stuffed a potato down the pipe. Like this:



I am not recommending that you do this! However, say you did... What we have here is a device commonly known as a **potato cannon**. When you introduce a spark, you can ignite the fuel.

What is interesting, and the reason we are talking about such a device, is that a potato cannon can launch a potato about 500 feet through the air! There is a huge amount of energy in a tiny drop of gasoline.

HOW PETROL ENGINES WORK

Internal Combustion

The potato cannon uses the basic principle behind any reciprocating internal combustion engine: If you put a tiny amount of high-energy fuel (like gasoline) in a small, enclosed space and ignite it, an incredible amount of energy is released in the form of expanding gas. You can use that energy to propel a potato 500 feet. In this case, the energy is translated into potato motion. You can also use it for more interesting purposes. For example, if you can create a cycle that allows you to set off explosions like this hundreds of times per minute, and if you can harness that energy in a useful way, what you have is the core of a car engine!

Almost all cars currently use what is called a **four-stroke combustion cycle** to convert gasoline into motion. The four-stroke approach is also known as the **Otto cycle**, in honour of Nikolaus Otto, who invented it in 1867. The four strokes are as follows:

- Intake stroke
- Compression stroke
- Combustion stroke
- Exhaust stroke

A device called a **piston** replaces the potato in the potato cannon. The piston is connected to the **crank shaft** by a **connecting rod**. As the crankshaft revolves, it has the effect of "resetting the cannon." Here's what happens as the engine goes through its cycle:

1. The piston starts at the top, the intake valve opens, and the piston moves down to let the engine take in a cylinder-full of air and gasoline. This is the **intake stroke**. Only the tiniest drop of gasoline needs to be mixed into the air for this to work.
2. Then the piston moves back up to compress this fuel/air mixture. **Compression** makes the explosion more powerful.
3. When the piston reaches the top of its stroke, the spark plug emits a spark to ignite the gasoline. The gasoline charge in the cylinder **explodes**, driving the piston down. Once the piston hits the bottom of its stroke, the exhaust valve opens and the **exhaust** leaves the cylinder to go out the tail pipe.
4. Now the engine is ready for the next cycle, so it intakes another charge of air and gas.

Notice that the motion that comes out of an internal combustion engine is **rotational**, while the motion produced by a potato cannon is **linear** (straight line). In an engine, the linear motion of the pistons is converted into rotational motion by the crank shaft. The rotational motion is nice because we plan to turn (rotate) the car's wheels with it anyway.

Counting cylinders

The core of the engine is the cylinder, with the piston moving up and down inside the cylinder. The engine described above has one cylinder. That is typical of most lawn mowers, but most cars have more than one cylinder (four, six and eight cylinders are common). In a multi-cylinder engine, the cylinders usually are arranged in one of three ways: **inline**, **V** or **flat** (also known as horizontally opposed or boxer), as shown in the following figures.

HOW PETROL ENGINES WORK

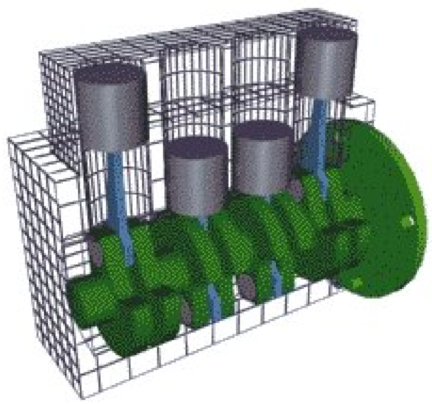


Figure 2. Inline - The cylinders are arranged in a line in a single bank.

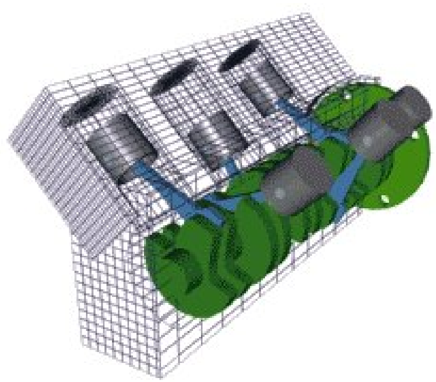


Figure 3. V - The cylinders are arranged in two banks set at an angle to one another.

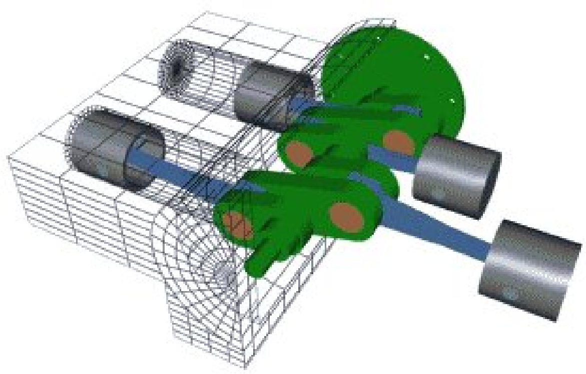


Figure 4. Flat - The cylinders are arranged in two banks on opposite sides of the engine.

HOW PETROL ENGINES WORK

Different configurations have different advantages and disadvantages in terms of smoothness, manufacturing-cost and shape characteristics. These advantages and disadvantages make them more suitable for certain vehicles.

Displacement

The combustion chamber is the area where compression and combustion take place. As the piston moves up and down, you can see that the size of the combustion chamber changes. It has some maximum volume as well as a minimum volume. The difference between the maximum and minimum is called the **displacement** and is measured in litres or CCs (Cubic Centimetres, where 1,000 cubic centimetres equals a litre).

Here are some examples:

- A chainsaw might have a 40 cc engine.
- A motorcycle might have a 500 cc or a 750 cc engine.
- A sports car might have a 5.0 litre (5,000 cc) engine.

Most normal car engines fall somewhere between 1.5 litre (1,500 cc) and 4.0 litres (4,000 cc)

If you have a 4-cylinder engine and each cylinder displaces half a litre, then the entire engine is a "2.0 litre engine." If each cylinder displaces half a litre and there are six cylinders arranged in a V configuration, you have a "3.0 litre V-6."

Generally, the displacement tells you something about how much power an engine can produce. A cylinder that displaces half a litre can hold twice as much fuel/air mixture as a cylinder that displaces a quarter of a litre, and therefore you would expect about twice as much power from the larger cylinder (if everything else is equal). Therefore, a 2.0 litre engine is roughly half as powerful as a 4.0 litre engine.

You can get more displacement in an engine either by increasing the number of cylinders or by making the combustion chambers of all the cylinders bigger (or both).

Other Parts of an Engine

Spark plug
The spark plug supplies the spark that ignites the air/fuel mixture so that combustion can occur. The spark must happen at just the right moment for things to work properly.

Valves
The intake and exhaust valves open at the proper time to let in air and fuel and to let out exhaust. Note that both valves are closed during compression and combustion so that the combustion chamber is sealed.

Piston
A piston is a cylindrical piece of metal that moves up and down inside the cylinder.

HOW PETROL ENGINES WORK

Piston rings
Piston rings provide a sliding seal between the outer edge of the piston and the inner edge of the cylinder. The rings serve two purposes:

- They prevent the fuel/air mixture and exhaust in the combustion chamber from leaking into the sump during compression and combustion.
- They keep oil in the sump from leaking into the combustion area, where it would be burned and lost.

Most cars that "burn oil" and have to have a Litre added every 1,000 miles are burning it because the engine is old and the rings no longer seal things properly.

Connecting rod
The connecting rod connects the piston to the crankshaft. It can rotate at both ends so that its angle can change as the piston moves and the crankshaft rotates.

Crank shaft
The crank shaft turns the pistons up and down motion into circular motion just like a crank on a jack-in-the-box does.

Sump
The sump surrounds the crankshaft. It contains some amount of oil, which collects in the bottom of the sump (the oil pan).

What Can Go Wrong

So you go out one morning and your engine will turn over but it won't start... What could be wrong? Now that you know how an engine works, you can understand the basic things that can keep an engine from running. Three fundamental things can happen: a bad fuel mix, lack of compression or lack of spark. Beyond that, thousands of minor things can create problems, but these are the "big three." Based on the simple engine we have been discussing, here is a quick run-down on how these problems affect your engine:

Bad fuel mix - A bad fuel mix can occur in several ways:

- You are out of gas, so the engine is getting air but no fuel.
- The air intake might be clogged, so there is fuel but not enough air.
- The fuel system might be supplying too much or too little fuel to the mix, meaning that combustion does not occur properly.
- There might be an impurity in the fuel (like water in your gas tank) that makes the fuel not burn.

Lack of compression - If the charge of air and fuel cannot be compressed properly, the combustion process will not work, as it should. Lack of compression might occur for these reasons:

- Your piston rings are worn (allowing air/fuel to leak past the piston during compression).
- The intake or exhaust valves are not sealing properly, again allowing a leak during compression.
- There is a hole in the cylinder.

HOW PETROL ENGINES WORK

The most common "hole" in a cylinder occurs where the top of the cylinder (holding the valves and spark plug and also known as **the cylinder head**) attaches to the cylinder itself. Generally, the cylinder and the cylinder head bolt together with a thin **gasket** pressed between them to ensure a good seal. If the gasket breaks down, small holes develop between the cylinder and the cylinder head, and these holes cause leaks.

Lack of spark - The spark might be nonexistent or weak for a number of reasons:

- If your spark plug or the wire leading to it is worn out, the spark will be weak.
- If the wire is cut or missing, or if the system that sends a spark down the wire is not working properly, there will be no spark.
- If the spark occurs either too early or too late in the cycle (i.e. if the **ignition timing** is off), the fuel will not ignite at the right time, and this can cause all sorts of problems.

Other Problems

Many other things can go wrong. For example:

- If the battery is dead, you cannot turn over the engine to start it.
- If the bearings that allow the crankshaft to turn freely are worn out, the crankshaft cannot turn so the engine cannot run.
- If the valves do not open and close at the right time or at all, air cannot get in and exhaust cannot get out, so the engine cannot run.
- If someone sticks a potato up your tailpipe, exhaust cannot exit the cylinder so the engine will not run.
- If you run out of oil, the piston cannot move up and down freely in the cylinder, and the engine will seize.

In a properly running engine, all of these factors are within tolerance. As you can see, an engine has a number of systems that help it do its job of converting fuel into motion. Most of these subsystems can be implemented using different technologies, and better technologies can improve the performance of the engine.

NOTE: This article is an extract from the web site How Stuff Works at
www.howstuffworks.com