Tech Torque

How Diesel Engines Work

One of the most popular How Stuff Works articles is How Car Engines Work, which explains the basic principles behind internal combustion, discusses the four-stroke cycle and talks about all of the subsystems that help your car's engine to do its job. For a long time after we published that article, one of the most common questions asked (and one of the most frequent suggestions made in the suggestion box) was, "What is the difference between a gasoline and a diesel engine?"

Photo courtesy DaimlerChrysler
2.7-Liter CRD Direct-Injection diesel engine, 2003 Jeep® Grand Cherokee

The Diesel Cycle

Rudolf Diesel developed the idea for the diesel engine and obtained the German patent for it in 1892. His goal was to create an engine with **high efficiency**. Gasoline engines had been invented in 1876 and, especially at that time, were not very efficient.

Photo courtesy DaimlerChrysler

Atego six-cylinder diesel engine

The main differences between the gasoline engine and the diesel engine are:

- A gasoline engine intakes a mixture of gas and air, compresses it and ignites the mixture with a spark. A diesel engine takes in just air, compresses it and then injects fuel into the compressed air. The heat of the compressed air lights the fuel spontaneously.
- A gasoline engine compresses at a ratio of 8:1 to 12:1, while a diesel engine compresses at a ratio of 14:1 to as high as 25:1. The higher compression ratio of the diesel engine leads to better efficiency.
- Gasoline engines generally use either carburetion, in which the air and fuel is mixed long before the air enters the cylinder, or port fuel injection, in which the fuel is injected just prior to the intake stroke (outside the cylinder). Diesel engines use direct fuel injection -- the diesel fuel is injected directly into the cylinder.

Note that the diesel engine has no spark plug, that it intakes air and compresses it, and that it then injects the fuel directly into the combustion chamber (direct injection). It is the heat of the compressed air that lights the fuel in a diesel engine.

Direct Injection

The injector on a diesel engine is its most complex component and has been the subject of a great deal of experimentation -- in any particular engine it may be located in a variety of places. The injector has to be able to withstand the temperature and pressure inside the cylinder and still deliver the fuel in a fine mist. Getting the mist circulated in the cylinder so that it is evenly distributed is also a problem, so some diesel engines employ special induction valves, pre-combustion chambers or other devices to swirl the air in the combustion chamber or otherwise improve the ignition and combustion process.

One big difference between a diesel engine and a gas engine is in the injection process. Most car engines

use port injection or a carburettor rather than direct injection. In a car engine, therefore, all of the fuel is loaded into the cylinder during the intake stroke and then compressed. The compression of the fuel/air mixture limits the compression ratio of the engine -- if it compresses the air too much, the fuel/air mixture spontaneously ignites and causes **knocking**. A diesel compresses only air, so the compression ratio can be much higher.

The higher the compression ratio, the more power is generated. Some diesel engines contain a **glow plug** of some sort (not shown in this figure). When a diesel engine is cold, the compression process may not raise the air to a high enough temperature to ignite the fuel. The glow plug is an electrically heated wire (think of the hot wires you see in a toaster) that helps ignite the fuel when the engine is cold so that the engine can start. According to Cley Brotherton, a Journeyman heavy equipment technician:

> All functions in a modern engine are controlled by the ECM communicating with an elaborate set of sensors measuring everything from R.P.M. to engine coolant and oil temperatures and even engine position (i.e. T.D.C.). Glow plugs are rarely used today on larger engines. The ECM senses ambient air temperature and retards the timing of the engine in cold weather so the injector sprays the fuel at a later time. The air in the cylinder is compressed more, creating more heat, which aids in starting.

Smaller engines and engines that do not have such advanced computer control use glow plugs to solve the cold-starting problem.

Diesel Fuel

If you have ever compared diesel fuel and gasoline, you know that they are different. They certainly smell different. Diesel fuel is heavier and oilier. Diesel fuel evaporates much more slowly than gasoline -- its boiling point is actually higher than the boiling point of water. You will often hear diesel fuel referred to as "diesel oil" because it is so oily.

Photo courtesy DaimlerChrysler

Mercedes-Benz Conecto H with six-cylinder OM 457 hLA Euro 3 diesel engine

Diesel fuel evaporates more slowly because it is heavier. It contains more carbon atoms in longer chains than gasoline does (gasoline is typically C_9H_{20}, while diesel fuel is typically $C_{14}H_{30}$). It takes less refining to create diesel fuel, which is why it is generally cheaper than gasoline.

Diesel fuel has a **higher energy density** than gasoline. On average, 1 gallon (3.8 L) of diesel fuel contains approximately $155x10^6$ joules (147,000 BTU), while 1 gallon of gasoline contains $132x10^6$ joules (125,000 BTU). This, combined with the improved efficiency of diesel engines, explains why diesel engines get better mileage than equivalent gasoline engines.

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