Internal combustion engine

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An **internal combustion engine** (**ICE**) is a heat engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine blades, or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy. The first commercially successful internal combustion engine was created by Étienne Lenoir around 1859[1] and the first modern internal combustion engine was created in 1864 by Siegfried Marcus.

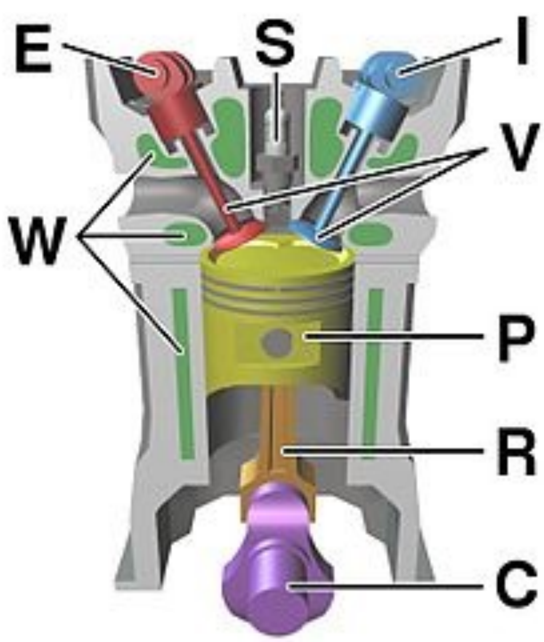

Diagram of a cylinder as found in 4-stroke gasoline engines.:

C – crankshaft.
E – exhaust camshaft.
I – inlet camshaft.
P – piston.
R – connecting rod.
S – spark plug.
V – valves. red: exhaust, blue: intake.
W – cooling water jacket.
gray structure – engine block.

The term *internal combustion engine* usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the six-stroke piston engine and the Wankel rotary engine. A second class of internal combustion engines use continuous combustion: gas turbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described.[1][2] Firearms are also a form of internal combustion engine.[2]
Internal combustion engines are quite different from external combustion engines, such as steam or Stirling engines, in which the energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids can be air, hot water, pressurized water or even liquid sodium, heated in a boiler. ICEs are usually powered by energy-dense fuels such as gasoline or diesel, liquids derived from fossil fuels. While there are many stationary applications, most ICEs are used in mobile applications and are the dominant power supply for vehicles such as cars, aircraft, and boats.
Typically an ICE is fed with fossil fuels like natural gas or petroleum products such as gasoline, diesel fuel or fuel oil. There's a growing usage of renewable fuels like biodiesel for compression ignition engines and bioethanol for spark ignition engines. Hydrogen is sometimes used, and can be made from either fossil fuels or renewable energy.

Energy efficiency

Once ignited and burnt, the combustion products—hot gases—have more available thermal energy than the original compressed fuel-air mixture (which had higher chemical energy). The available energy is manifested as high temperature and pressure that can be translated into work by the engine. In a reciprocating engine, the high-pressure gases inside the cylinders drive the engine's pistons.

Once the available energy has been removed, the remaining hot gases are vented (often by opening a valve or exposing the exhaust outlet) and this allows the piston to return to its previous position (top dead center, or TDC). The piston can then proceed to the next phase of its cycle, which varies between engines. Any heat that is not translated into work is normally considered a waste product and is removed from the engine either by an air or liquid cooling system.
Internal combustion engines are primarily heat engines, and as such their theoretical efficiency can be calculated by idealized thermodynamic cycles. The efficiency of a theoretical cycle cannot exceed that of the Carnot cycle, whose efficiency is determined by the difference between the lower and upper operating

temperatures of the engine. The upper operating temperature of a terrestrial engine is limited by the thermal stability of the materials used to construct it. All metals and alloys eventually melt or decompose, and there is significant researching into ceramic materials that can be made with greater thermal stability and desirable structural properties. Higher thermal stability allows for greater temperature difference between the lower and upper operating temperatures, hence greater thermodynamic efficiency.

The thermodynamic limits assume that the engine is operating under ideal conditions: a frictionless world, ideal gases, perfect insulators, and operation for infinite time. Real world applications introduce complexities that reduce efficiency. For example, a real engine runs best at a specific load, termed its power band. The engine in a car cruising on a highway is usually operating significantly below its ideal load, because it is designed for the higher loads required for rapid acceleration.[*citation needed*] In addition, factors such as wind resistance reduce overall system efficiency. Engine fuel economy is measured in miles per gallon or in liters per 100 kilometres. The volume of hydrocarbon assumes a standard energy content.

Most steel engines have a thermodynamic limit of 37 %. Even when aided with turbochargers and stock efficiency aids, most engines retain an *average* efficiency of about 18 %-20 %.[14] Rocket engine efficiencies are much better, up to 70 %, because they operate at very high temperatures and pressures and can have very high expansion ratios.[15] Electric motors are better still, at around 85 - 90 % efficiency or more, but they rely on an external power source (often another heat engine at a power plant subject to similar thermodynamic efficiency limits).

There are many inventions aimed at increasing the efficiency of IC engines. In general, practical engines are always compromised by trade-offs between different properties such as efficiency, weight, power, heat, response, exhaust emissions, or noise. Sometimes economy also plays a role in not only the cost of manufacturing the engine itself, but also manufacturing and distributing the fuel. Increasing the engine's efficiency brings better fuel economy but only if the fuel cost per energy content is the same.

Internal combustion engine. (n.d.). In *Wikipedia*. Retrieved August 21, 2015, from https://en.wikipedia.org/wiki/Internal_combustion_engine