

Gasoline engine

Gasoline engine, any of a class of internal-combustion engines that generate power by burning a volatile liquid fuel (gasoline or a gasoline mixture such as ethanol) with ignition initiated by an electric spark. Gasoline engines can be built to meet the requirements of practically any conceivable power-plant application, the most important being passenger automobiles, small trucks and buses, general aviation aircraft, outboard and small inboard marine units, moderate-sized stationary pumping, lighting plants, machine tools, and power tools. Four-stroke gasoline engines power the vast majority of automobiles, light trucks, medium-to-large motorcycles, and lawn mowers. Two-stroke gasoline engines are less common, but they are used for small outboard marine engines and in many handheld landscaping tools such as chain saws, hedge trimmers, and leaf blowers.

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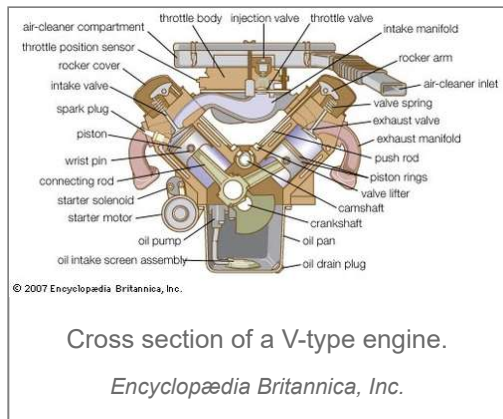
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Engine types

Gasoline engines can be grouped into a number of types depending on several criteria, including their application, method of fuel management, ignition, piston-and-cylinder or rotor arrangement, strokes per cycle, cooling system, and valve type and location. In this section they are described within the context of two basic engine types: piston-and-cylinder engines and rotary engines. In

a piston-and-cylinder engine the pressure produced by combustion of gasoline creates a force on the head of a piston that moves the length of the cylinder in a reciprocating, or back-and-forth, motion. This force drives the piston away from the head of the cylinder and performs work. The rotary engine, also called the Wankel engine, does not have conventional cylinders fitted with reciprocating pistons. Instead, the gas pressure acts on the surfaces of a rotor, causing the rotor to turn and thus perform work.

Piston-and-cylinder engines

Most gasoline engines are of the reciprocating piston-and-cylinder type. The essential components of the piston-and-cylinder engine are shown in the [figure](#). Almost all engines of this type follow either the four-stroke cycle or the two-stroke cycle.

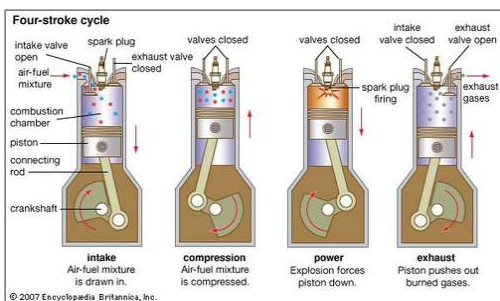
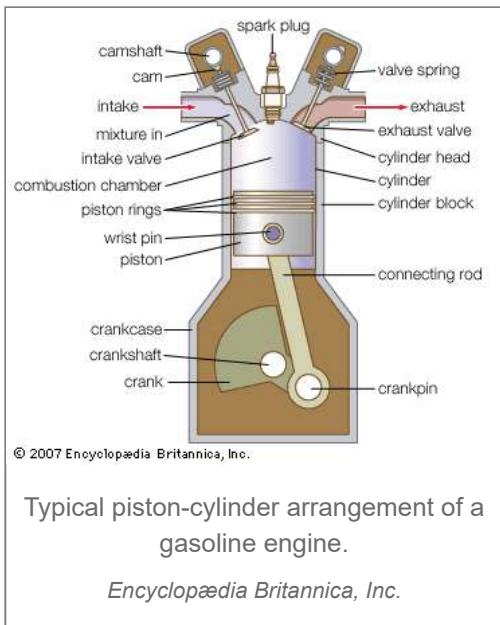
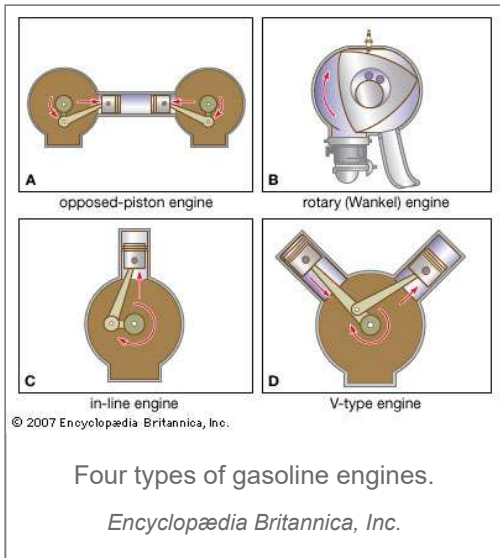
Four-stroke cycle

Of the different techniques for recovering the power from the combustion process, the most important so far has been the four-stroke cycle, a conception first developed in the late 19th century. The four-stroke cycle is illustrated in the [figure](#). With the inlet valve open, the piston first descends on the intake stroke. An ignitable mixture of gasoline vapour and air is drawn into the cylinder by the partial vacuum thus created. The mixture is compressed as the piston ascends on the compression stroke with both valves closed. As the end of the stroke is approached, the charge is ignited by an electric spark. The power stroke follows, with both valves still closed and the gas pressure, due to the expansion of the burned gas, pressing on the piston head or crown. During the exhaust stroke the ascending piston forces the spent products of combustion through the open exhaust valve. The cycle then repeats itself. Each cycle thus requires four strokes of the piston—intake, compression, power, and exhaust—and two revolutions of the crankshaft.

A disadvantage of the four-stroke cycle is that only half as many power strokes are completed as in the two-stroke cycle (*see below*) and only half as much power can be expected from an engine of a given size at a given operating speed. The four-stroke cycle, however, provides more positive clearing out of exhaust gases (scavenging) and reloading of the cylinders, reducing the loss of fresh charge to the exhaust.

Two-stroke cycle

In the original two-stroke cycle (as developed in 1878), the compression and power stroke of the four-stroke cycle are carried out without the inlet and exhaust strokes, thus requiring only one revolution of the crankshaft to complete the cycle. The fresh fuel mixture is forced into the cylinder through circumferential ports by a rotary blower (*see figure*) in the two-stroke-cycle

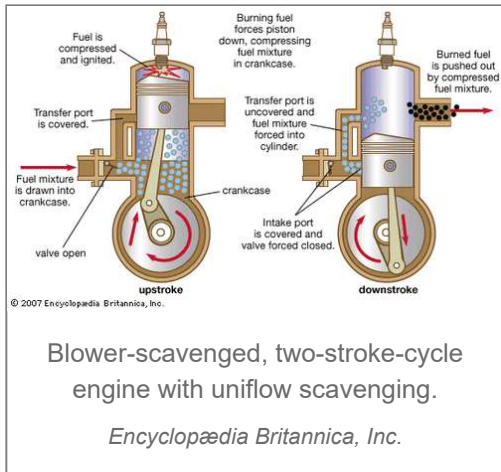


internal-combustion engine: four-stroke cycle

An internal-combustion engine goes through four strokes: intake, compression, combustion (power), and exhaust. As the piston moves during each stroke, it turns the crankshaft.

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engine of a so-called uniflow type. The exhaust gases pass through poppet valves in the cylinder head that are opened and closed by a cam-follower mechanism. The valves are timed to begin opening toward the end of the power stroke, after the cylinder pressure has dropped appreciably. The inlet ports in the cylinder wall start to uncover after the exhaust opening has decreased the cylinder pressure to the inlet pressure produced by the blower. The exhaust valves are allowed to remain open for a few degrees of crank rotation after the inlet ports have been covered by the rising piston on the compression stroke, thus allowing the persistency of flow to scavenge the cylinder more thoroughly. The compression and power strokes are similar to those of the four-stroke engine.



A simplified version of the two-stroke-cycle engine was developed some years later (introduced in 1891) by using crankcase compression to pump the fresh charge into the cylinder. Instead of intake ports extending entirely around the lower cylinder wall, this engine has intake ports only halfway around; a second set of ports starts a little higher in the cylinder wall in the other half of the cylinder bore. These larger ports lead to the exhaust system. The inlet ports connect to a transfer passage leading to the fully enclosed crankcase. A spring-loaded

inlet valve admits air into the crankcase on the upward, or compression, stroke of the piston. Air trapped in the crankcase is compressed by the descent of the piston on its power stroke. The piston thus uncovers the exhaust ports near the end of the power stroke, and slightly later it uncovers the inlet, or transfer, port on the opposite side of the cylinder to admit the compressed fresh mixture from the crankcase. The top face of the piston is designed to provide a deflector or baffle that directs the fresh load upward on the inlet side of the cylinder and then downward on the exhaust side, thus pushing the spent gases of the previous cycle out through the exhaust port on that side. This outflow continues after the inlet ports are covered by the rising piston on the compression stroke, until the exhaust ports are covered and compression of the fresh load begins. This loading process, called loop scavenging, is the simplest known method of replacing the exhaust products with a fresh mixture and creating a cycle with only compression and power strokes.

Such a system is used in many small gasoline engines (e.g., small outboard motors) and for gasoline-powered appliances. A disadvantage is that the return flow of the gases causes a slight loss of fresh charge through the exhaust ports. Because of this loss, carburetor engines operating on the two-stroke cycle lack the fuel economy of four-stroke engines. The loss can be avoided by equipping them with fuel-injection systems (see *below*) instead of carburetors and injecting the fuel directly into the cylinders after scavenging. Such an arrangement is

attractive as a means of attaining high power output from a relatively small engine, and development of the turbocharger (see *below* Supercharger) for this application holds promise of further improvement.

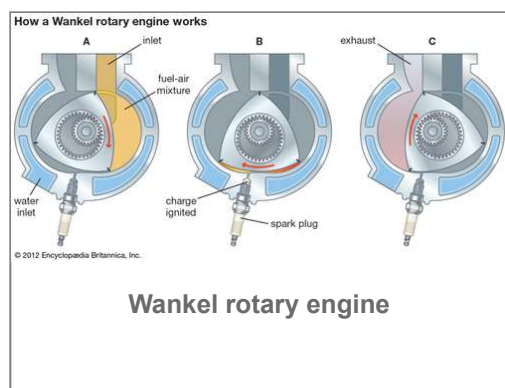
Opposed-piston engines

The opposed-piston engine also provides uniflow scavenging. This engine (see part A of the [figure](#)) has two pistons moving in opposite directions in the same cylinder. Two sets of ports extending entirely around the cylinder bore are located so that one set is covered and uncovered by one piston and the other set is controlled by the second piston. A second crankshaft, to which the upper pistons are attached, is located at the top of the engine, and the two shafts are connected by gears.

The opposed-piston design has two major advantages: reciprocating masses move in opposite directions, providing excellent balance; and the poppet valves necessary in other uniflow-scavenged two-stroke-cycle engines are eliminated.

Rotary (Wankel) engines

The rotary-piston internal-combustion engine developed in Germany is radically different in structure from conventional reciprocating piston engines. This engine was conceived by Felix Wankel, a specialist in the design of sealing devices, and experimental units were built and tested by a German firm beginning in 1956. Instead of pistons that move up and down in cylinders, the Wankel engine has an equilateral triangular orbiting rotor. The rotor turns in a closed chamber, and the three apexes of the rotor maintain a continuous sliding contact with the curved inner surface of the casing. The curve-sided rotor forms three crescent-shaped chambers between its sides and the curved wall of the casing. The volumes of the chambers vary with rotor position. Maximum volume is attained in each chamber when the side of the rotor forming it is parallel with the minor diameter of the casing; the volume is reduced to a minimum when the rotor side is parallel with the major diameter. Shallow pockets recessed in the flank of the rotor control the shape of the combustion chambers and establish the compression ratio of the engine.



In turning about its central axis, the rotor must follow a circular orbit about the geometric centre of the casing. The necessary orbiting rotation is attained by means of a central bore in the rotor in which an internal gear is fitted to mesh with a stationary pinion fixed immovably to the centre of the casing. The rotor is guided by fitting its central bore to an eccentric formed on the output shaft

One cycle of the Wankel rotary engine, showing (A) intake, (B) ignition, and (C) exhaust stages.

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that passes through the centre of the stationary pinion. This eccentric also harnesses the rotor to the shaft so that torque is applied when gas pressure is exerted against the rotor flanks as the fuel and air charges burn.

A 3-to-1 gear ratio causes the output shaft to turn three times as fast as the rotor turns about the eccentric. Each quarter turn of the rotor completes an expansion or a compression, permitting intake, compression, expansion, and exhaust to be accomplished during one turn of the rotor. The only moving parts are the rotor and the output shaft.

The fuel mixture is supplied by a carburetor and enters the combustion chambers through an intake port in one of the end plates of the casing. An exhaust port is formed in one of the flattened sides of the casing wall, and a spark plug is located in a pocket communicating with the chambers through a small throat in the opposite side of the casing wall.

The rotor and its gears and bearings are lubricated and cooled by oil circulating through the hollow rotor. The apex vanes are lubricated by a small amount of oil added to the fuel in proportions as low as 1 to 200. Water is circulated through cooling jackets in the casing, the entrance to which is located adjacent to the spark plug, where the temperature tends to be highest.

Maintaining pressure-tight joints by suitable seals at the apexes and on the end faces of the rotor is a major design problem. Radial sliding vanes are fitted in slots at the three apex edges and kept in contact with the casing by expander springs. The end faces of the rotor are sealed by arc-shaped segmental rings fitted in grooves close to the curved edges of the rotor and pressed against the casing by flat springs.

The major advantages of the Wankel engine are its small space requirements and low weight per horsepower, smooth and vibrationless operation, quiet operation, and low manufacturing costs resulting from mechanical simplicity. The absence of inertial forces from reciprocating parts and the elimination of spring-closed poppet valves permit operation at much higher speed than is practical for reciprocating piston engines, an advantage because shaft speed must be high for optimum performance. The induction of fresh fuel mixture and exhaust are more effective because the ports are opened and closed more rapidly than with poppet valves, and gas flow through them is almost continuous. Heat transfer and the resulting cooling requirement are low because the jacketed surface is small. Lower weight and a lower centre of gravity make it much safer in an automobile in the event of a collision. However, competitive fuel economies and the higher development and manufacturing costs of meeting emission standards have limited the use of the Wankel engine in production vehicles, with only the Mazda Motor Corporation marketing any substantial number.

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