

# Automotive engine

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**The component of the motor vehicle that converts the chemical energy in fuel into mechanical energy for power.** The automotive engine also drives the generator and various accessories, such as the air-conditioning compressor and power-steering pump. *See also:* AUTOMOTIVE CLIMATE CONTROL; AUTOMOTIVE ELECTRICAL SYSTEM; AUTOMOTIVE STEERING.

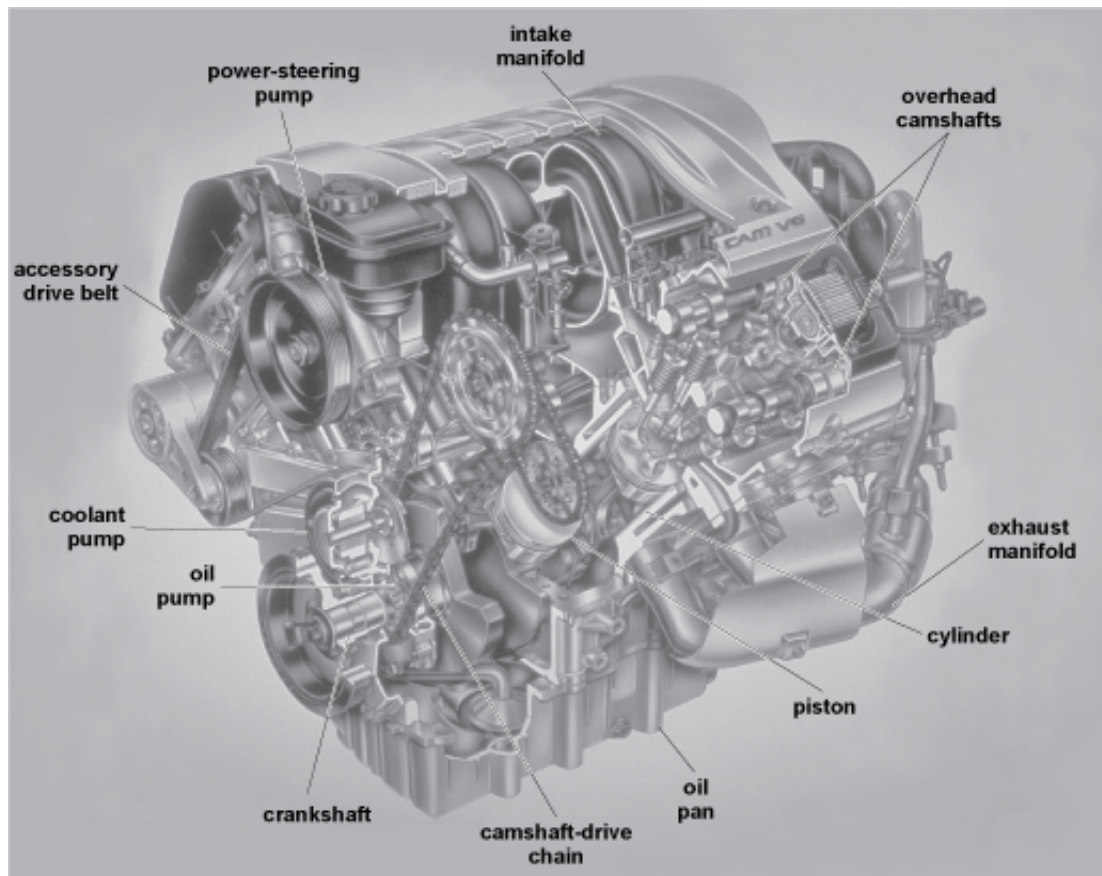
Early motor vehicles were powered by a variety of engines, including steam and gasoline, as well as by electric motors. The flexibility of the gasoline engine operating on the four-stroke Otto cycle soon made this engine predominant, and it remains the dominant automotive power plant. The basic modern automotive engine (see **illustration**) is a gasoline- burning, liquid-cooled, spark-ignition, four-stroke-cycle, multicylinder engine. It has the intake and exhaust valves in the cylinder head, and electronically controlled ignition and fuel injection. *See also:* ENGINE.

## Otto-cycle engine

An Otto-cycle engine is an internal combustion piston engine that may be designed to operate on either two strokes or four strokes of a piston that moves up and down in a cylinder. Generally, the automotive engine uses four strokes to convert chemical energy to mechanical energy through combustion of gasoline or similar hydrocarbon fuel. The heat produced is converted into mechanical work by pushing the piston down in the cylinder. A connecting rod attached to the piston transfers this energy to a rotating crankshaft. *See also:* GASOLINE; INTERNAL COMBUSTION ENGINE; OTTO CYCLE.

*Cylinder arrangement.* Engines having from 1 to 16 cylinders in in-line, flat, horizontally opposed, or V-type cylinder arrangements have appeared in production vehicles, progressing from simple single-cylinder engines at the beginning of the twentieth century to complex V-12 and V-16 engines by the early 1930s. Increased vehicle size and weight played a major role in this transition, requiring engines with additional displacement and cylinders to provide acceptable performance.

High-volume usage of the V-8 engine began in the mid-1930s and accelerated dramatically after World War II, until it was the predominant engine used in American-built vehicles by the late 1950s. Manufacturers in other countries continued large-volume production of smaller engines with four and six cylinders, primarily because of significantly higher fuel costs. As vehicle size and weight increased, average engine displacement also increased until the early 1970s, when V-8 engines approaching 500 in.<sup>3</sup> (8 liters) displacement were in production.



Automotive engine, which has six cylinders, double-overhead camshafts, 24-valve electronic coil-on-plug spark ignition, and multiport fuel injection. (*Oldsmobile Division, General Motors Corp.*)

However, oil shortages in 1973–1974 and 1979–1980 reversed this trend, and V-8 engine usage dropped in favor of engines with four and six cylinders.

**Turbocharger and supercharger.** To provide acceptable vehicle performance with a smaller engine, forced induction may be used. A turbocharger or supercharger forces more air into the intake manifold, allowing the engine to burn more fuel and produce more power. The turbocharger is a centrifugal air compressor driven by an exhaust-gas-powered turbine mounted on a common shaft. The energy in the exhaust gas spins the turbine, which spins the compressor, forcing more air or air-fuel mixture into the combustion chambers. In a typical passenger car, this may increase engine power output by up to 40%.

A supercharger, which is belt-driven from the engine crankshaft, may be used instead of a turbocharger. The supercharger does not have the brief acceleration lag, or so-called turbo lag, that is found objectionable by many drivers of vehicles with turbocharged engines. *See also:* AUTOMOBILE; COMBUSTION CHAMBER; COMPRESSOR; MUFFLER; SUPERCHARGER; TURBINE; TURBOCHARGER.

*Emissions.* In the United States, passenger-car emission standards became effective in California in 1966 and in the other 49 states in 1968. These regulations began placing limits on crankcase, exhaust, and evaporative emissions into the atmosphere. The limits became increasingly stringent over the years, requiring the use of catalytic converters and unleaded gasoline beginning with 1975-model cars. Because more accurate fuel metering and ignition timing were required on engines to meet the tightening standards, electronic controls became necessary. As a result, fuel injection replaced the carburetor on automotive engines.

*Electronic controls.* Ignition, fuel, and emissions systems are integrated under an electronic engine control system. The system utilizes an onboard computer to provide management of various engine-operating parameters and emissions devices. The computer, known as the powertrain control module, may also control shifting of the automatic transmission or transaxle.

## Engine design trends

In many automotive engines, the camshaft, which operates the intake and exhaust valves, has been moved from the cylinder block to the cylinder head (see illus.). This overhead-camshaft arrangement allows the use of more than two valves per cylinder, with various multivalve engines having three to five. Some overhead-camshaft engines have only one camshaft, while others have two camshafts, one for the intake valves and one for the exhaust valves. A V-type engine may have four camshafts, two for each bank of cylinders. Some multivalve overhead-camshaft engines have the power and performance of a turbocharged engine of similar size.

Most engines have fixed valve timing, regardless of number of camshafts or their location. Variable valve timing can improve fuel economy and minimize exhaust emissions, especially on multivalve engines. At higher speeds, volumetric efficiency can be increased by opening the intake valves earlier. One method drives the camshaft through an electrohydraulic mechanism that, on signal from the engine computer, rotates the intake camshaft ahead about  $10^\circ$ . Another system varies both valve timing and valve lift by having two cam lobes, each with a different profile, that the computer can selectively engage to operate each valve. Computer-controlled solenoids for opening and closing the valves will allow elimination of the complete valve train, including the camshaft, from the automotive piston engine while providing variable valve timing and lift.

*Materials trends.* Historically, major engine components have been made from ferrous metals, either by casting or by forging. However, emphasis on weight reduction for improved fuel economy has greatly increased the usage of aluminum for cylinder blocks, cylinder heads, and other engine components. Some engine covers and intake manifolds are made of magnesium. Internal engine parts, such as connecting rods, sprockets, oil-pump rotors, and valve guides, are cast or forged to nearly net shape using powder metallurgy. High-speed engines may use titanium connecting rods to reduce reciprocating mass. *See also:* POWDER METALLURGY.

Parts such as engine covers, intake manifolds, and oil pans also can be fabricated of plastic or composite materials. These materials provide weight savings while reducing engine noise and vibration. Ceramic engine parts and

coatings will allow engine operation at higher temperatures, raising engine efficiency. Ceramic-lined exhaust ports in the cylinder head can lower its temperature while increasing the effectiveness of the catalytic converter.

*Fuel-metering trends.* With the introduction of electronic controls, a device was added to the carburetor to automatically adjust the air-fuel ratio in response to feedback from an exhaust-gas oxygen sensor. Demand for more accurate fuel metering resulted in the feedback carburetor being replaced by a similarly located throttle-body fuel-injection unit. It meters fuel through the computer-controlled pulsing of one or two solenoid-operated fuel injectors. Further improvements in engine power, fuel economy, and exhaust emissions are provided by multiport fuel injection, which places a fuel injector in each intake port. Solenoid-operated fuel injectors can be pulsed or energized in simultaneous, group, or sequential fashion—the last energizes each injector individually in firing-order sequence.

*Ignition trends.* On many automotive engines, the ignition distributor has been replaced with computer-controlled distributorless ignition; this in turn is being replaced with coil-on-plug or direct ignition, in which an ignition coil sits directly above, and is connected to, each spark plug. Some engines have two spark plugs per cylinder to provide higher power output with cleaner combustion and less tendency for spark knock, or detonation. Spark knock can be monitored by a knock sensor, which signals the computer for less spark advance to prevent engine damage. The knock sensor also is used, especially with a supercharger or turbocharger, to allow engine operation on a more economical, lower-octane-rated fuel than otherwise would be required.

*Onboard diagnostic developments.* An onboard computer with self-diagnostic capability has become standard equipment for automotive engine control. The first generation of onboard diagnostics (OBD I) identified the failure of certain emission-control components. The second generation (OBD II), required for 1996 and later model vehicles, has additional capability, including detection of deterioration in performance of emission-control components throughout the life of the vehicle.

## Alternative engines

Alternative engine designs have been investigated as replacements for the four-stroke Otto-cycle piston engine, including the two-stroke, diesel, Stirling, Wankel rotary, gas turbine, and steam engines, as well as electric motors and hybrid power plants. However, only two engines are in mass production as automotive power plants: the four-stroke gasoline engine described above, and the diesel engine. Continuing improvements to the Otto-cycle piston engine, such as electronic controls and valve actuation and other changes in design and materials, appear to assure its predominance in the short term. *See also:* BATTERY; DIESEL ENGINE; ELECTRIC VEHICLE; FUEL CELL; GAS TURBINE; MOTOR; POWER PLANT; ROTARY ENGINE; SOLAR CELL; STEAM ENGINE; STIRLING ENGINE.

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