

Gasoline direct injection

Gasoline direct-injection engines generate the air/fuel mixture in the combustion chamber. During the induction stroke, only the combustion air flows through the open intake valve. The fuel is injected directly into the combustion chamber by special fuel injectors.

Overview

The demand for higher-power spark-ignition engines, combined with the requirement for reduced fuel consumption, were behind the “rediscovery” of gasoline direct injection. The principle is not a new one. As far back as 1937, an engine with mechanical gasoline direct injection took to the air in an airplane. In 1951 the “Gutbrod” was the first passenger car with a series-production mechanical gasoline direct-injection engine, and in 1954 the “Mercedes 300 SL” with a four-stroke engine and direct injection followed.

At that time, designing and building a direct-injection engine was a very complicated business. Moreover, this technology made extreme demands on the materials used. The engine’s service life was a further problem. These facts all contributed to it taking so long for gasoline direct injection to achieve its breakthrough.

Method of operation

Gasoline direct-injection systems are characterized by injecting the fuel directly into the combustion chamber at high pressure (Fig. 1). As in a diesel engine, air/fuel-mixture formation takes place inside the combustion chamber (internal mixture formation).

High-pressure generation

The electric fuel pump (Fig. 2, Pos. 19) delivers fuel to the high-pressure pump (4) at a presupply pressure of 3...5 bar. The latter pump generates the system pressure depending on the engine operating point (requested torque and engine speed). The highly pressurized fuel flows into and is stored in the fuel rail (Fig. 1, Pos. 6).

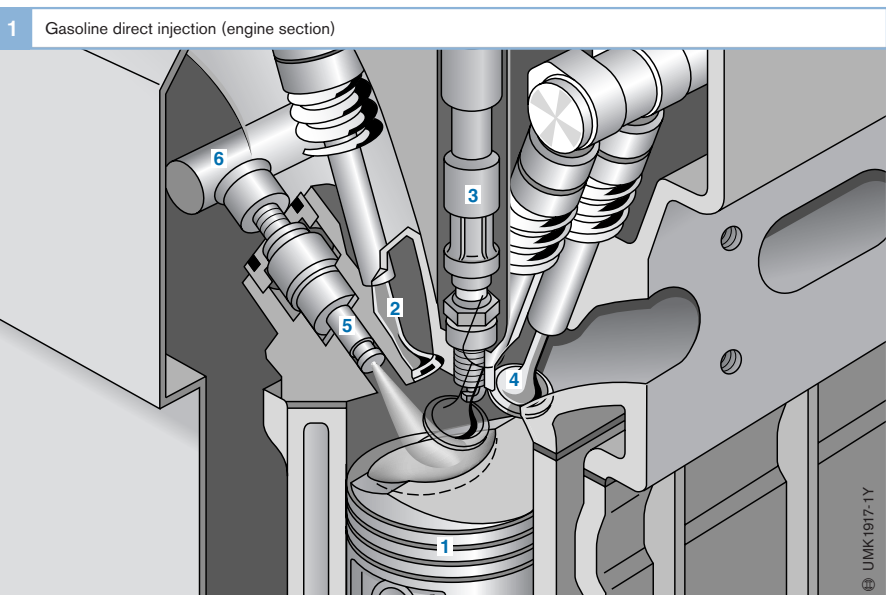


Fig. 1

- 1 Piston
- 2 Intake valve
- 3 Ignition coil and spark plug
- 4 Exhaust valve
- 5 High-pressure fuel injector
- 6 Fuel rail

The fuel pressure is measured with the high-pressure sensor and adjusted via the pressure-control valve (in the HDP1) or the fuel-supply control valve integrated in the HDP2/HDP5 to values ranging between 50 and 200 bar.

The high-pressure fuel injectors (5) are mounted on the fuel rail, also known as the “common rail”. These injectors are actuated by the engine ECU and spray the fuel into the cylinder combustion chambers.

Combustion process

In the case of gasoline direct injection, the combustion process is defined as the way in which mixture formation and energy conversion take place in the combustion chamber. The mechanisms are determined by the geometries of the combustion chamber and the intake manifold, and the injection point and the moment of ignition. Depending on the combustion process concerned, flows of air are generated in the combustion chamber. The relationship between injected fuel and air flow is extremely important, above all in

relation to those combustion processes which work with charge stratification (stratified concepts). In order to obtain the required charge stratification, the injector fuel injects the fuel into the air flow in such a manner that it evaporates in a defined area. The air flow then transports the mixture cloud in the direction of the spark plug so that it arrives there at the moment of ignition.

A combustion process is often made up of several different operating modes between which the process switches as a function of the engine operating point. Basically, the combustion processes are divided into two categories: stratified-charge and homogeneous combustion processes.

Homogeneous combustion process

In the case of the homogeneous combustion process, usually a generally stoichiometric mixture is formed in the combustion chamber in the engine map (Fig. 3a), i.e. an air ratio of $\lambda = 1$ always exists. In this way, the expensive exhaust-gas treatment of NO_x emissions which is required with lean mixtures is avoided. Homogeneous concepts are therefore set out to be emission-reducing concepts.

Fig. 2

- 1 Hot-film air-mass meter
- 2 Throttle device (ETC)
- 3 Intake-manifold pressure sensor
- 4 High-pressure pump
- 5 Charge-flow control valve
- 6 Fuel rail with high-pressure injector
- 7 Camshaft adjuster
- 8 Ignition coil with spark plug
- 9 Camshaft phase sensor
- 10 Lambda sensor
- 11 Primary catalytic converter
- 12 Lambda sensor
- 13 Exhaust-gas temperature sensor
- 14 NO_x accumulator-type catalytic converter
- 15 Lambda sensor
- 16 Knock sensor
- 17 Engine-temperature sensor
- 18 Speed sensor
- 19 Fuel-supply module with electric fuel pump

