Tips & Technology
For Bosch business partners

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Diesel injection

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Combustion methods for passenger vehicle diesel engines

The compression ratio of diesel engines, also known as compression-ignition engines, is so high (ε = 20 : 1 to 24 : 1) that the air heated on the compression stroke immediately ignites the diesel fuel injected. By comparison, the compression ratio of a standard gasoline engine is ε = 10 : 1.

Swirl chamber method with IDI engines

This combustion method employs a spherical or disk-shaped secondary combustion chamber (swirl chamber) connected to the cylinder combustion chamber by a tangential throat. During the compression stroke, the air entering via the throat is caused to swirl and the fuel is injected in this swirl. The fuel is injected in the direction of air motion, thus yielding a good fuel/air mixture. At the start of combustion, the fuel/air mixture is pressed through the throat into the cylinder chamber where it is mixed with the remaining combustion air. As compared to the pre-chamber method, there is less flow loss as the overflow cross-section is greater and thus more beneficial in terms of internal efficiency and fuel consumption. The positioning and shape of the spray and the spark plug position have to be carefully matched to the engine so as to produce good mixture formation at all engine speeds and loads. Rapid heating of the swirl chamber by the glow plug after cold starting is of course also essential. The development of unburnt hydrocarbons (blue smoke) in the exhaust gas on warm-up is prevented.

Pre-chamber method with IDI engines

The fuel is injected into a hot pre-chamber in which pre-combustion initiates good mixture formation with reduced ignition lag for main combustion. On hitting a specially designed baffle surface in the center of the chamber, the spray coming from a single-jet throttling-pintle nozzle (up to 300 bar) is split up and intensively mixed with the air. As combustion commences, the partially burnt fuel/air mixture is further heated and forced through bores at the bottom end of the pre-chamber into the main combustion chamber. Controlled post-glow (up to 3 minutes after cold starting with the Bosch Duraterm® depending on the coolant temperature) has a positive effect on emissions and helps to reduce noise in the warm-up phase .

In IDI engines, the glow plugs project into the secondary combustion chamber as opposed to the combustion chamber of the engine cylinder in DI engines.

Direct injection method with DI engines

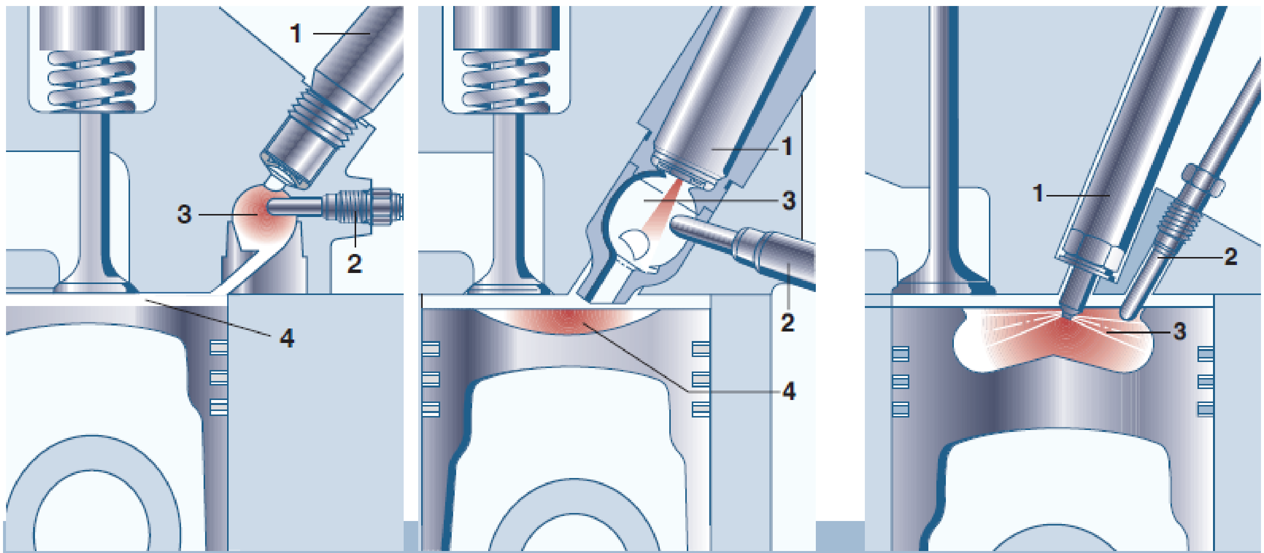
The processes such as fuel atomization, heating, vaporization and mixing with air described so far have to take place in quick succession in the case of direct injection of the diesel fuel into the combustion chamber. The specially shaped intake port in the cylinder head produces a swirl of air during the suction and compression strokes. The design of the piston surface with incorporated combustion chamber helps to promote the movement of air at the end of the compression stroke, i.e. at the start of injection. In this case use is made of a multi-hole nozzle with the spray position optimized to suit the combustion chamber design. The injection equipment has to satisfy greater demands in terms of position, number of injection orifices and fine atomization with small injection orifice diameters as well as an extremely high injection pressure to achieve the short injection time required.

Low-compression DI engines

A further diesel engine development is a reduction in compression ratio down to $\varepsilon = 15 : 1$. This makes the engines smaller, lighter, even more powerful and more ecological. Whilst driving, intermediate heating is required following engine cooling as a result of overrun or to promote particulate filter regeneration. These development trends confront the glow plug system with highly complex challenges.

By comparison**:** Direct injection engines where the combustion chamber is not divided exhibit less heat loss and thus a better starting performance than pre-chamber engines or swirl chamber engines with a divided combustion chamber.

Engines with indirect diesel injection IDI | **Direct injection engines DI**



Whirl chamber engine
1 Nozzle holder with injection nozzle
2 Glow plug
3 Whirl chamber
4 Combustion chamber

Prechamber engine
1 Nozzle holder with injection nozzle
2 Glow plug
3 Prechamber
4 Combustion chamber

Direct injection engine
1 Nozzle holder with injection nozzle
2 Glow plug
3 Combustion chamber