Tips & Technology

For Bosch business partners

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Diesel injection

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Common rail and piezo injectors

A brief outline of the common rail concept

In contrast to other systems which build up the pressure for each individual injection operation, injection and pressure generation take place separately with the common rail system. For this purpose, the rail acts as a high-pressure accumulator in which a fuel pressure is constantly maintained to match the engine operating status. Common rail systems are easy to integrate into a variety of engines. They also provide a broader scope of functions and a greater degree of freedom for the combustion process. This reduces emissions and makes diesel engines more thrifty and quieter running. The separation of pressure generation and engine speed leaves engine designers more scope with regard to the injection process as well as the metering and atomization of the fuel. Even at low engine speeds, common rail systems permit high injection pressures and thus fuller combustion of the fuel, resulting above all in the reduced formation of black smoke. It is also possible to increase the engine torque in the lower speed range. Common rail systems can easily be adapted to existing direct injection diesel engines. They consist of a high-pressure pump, the injection tubing, a high-pressure accumulator (common rail), the injectors and an electronic control unit as well as sensors and actuators.

Injectors form the heart of the system

The injectors spray fuel into the combustion chambers by way of the integrated nozzle. As the world's leading supplier of injection systems, Bosch can provide the ideal solution for every task: Modern, high-speed solenoid or piezo-controlled systems offer even greater design potential for the injection system. Injection is initiated by a switching signal from the control unit to the actuator. The accumulator pressure, the nozzle opening time and the number of injection orifices determine the quantity of fuel injected. In the first and second system generations for passenger vehicles, the actuators take the form of high-speed solenoid valves. In the 1800 and 2000 bar injectors, use is made of more advanced solenoid valve actuators to satisfy more exacting demands in terms of emissions, consumption, comfort and exhaust gas treatment.

The electronic control unit is in command

The EDC (Electronic Diesel Control) control unit operates with a microcontroller and a program and data memory employing flash technology. Its main functions are start of injection and injection time control as well as high-pressure regulation. The control unit is also responsible for a number of other functions such as glow control and system monitoring. By way of a Controller Area Network the control unit can also be linked to other systems such as electronic transmission control, ABS/ASR or the air conditioning system.

One technology spanning several generations

The first common rail system generation: The first system generation is designed for injection pressures of up to 1 400 bar for commercial vehicles and 1 350 bar for passenger cars. The injection system with high-pressure accumulator flexibly adapts the fuel pressure to the operating status. Special systems are also available for large locomotive and marine diesel engines. The second system generation with controlled-delivery pump: This generation attains an injection pressure of 1600 bar. The pump employs a metering unit to precisely match fuel delivery to the demand even at low pressures. The system helps to further reduce fuel consumption.

The third system generation with piezo injector

2003 saw the introduction of the third system generation – with an injection pressure of 1 600 bar. Employing piezo in-line injectors, the system for passenger cars provides scope for an even more flexible injection profile with pilot and secondary injection. Pressures of more than 2000 bar have been achieved on the basis of the third generation 1 600/1800 bar injector.

With the piezo injector, control of the nozzle needle is twice as fast as with solenoid injectors. This means that the start of injection, as well as the duration and profile, can be designed to achieve an even better engine map, which provides extra scope for setting the desired engine design priorities:

- Up to 3 % fuel saving
- 15 to 20 % lower emissions
- 5 to 7 % more power
- 3 dB(A) reduction in engine noise level compared to solenoid injectors

Further simplification is achieved by the slim design of the piezo in-line injector thanks to full integration of the actuator into the injector body.

In direct injection engines the noise of combustion is reduced by pilot injection, whilst secondary injection helps to lower the emission level. The number of possible pilot and secondary injection operations has been increased with each system generation, resulting in smoother running and a reduction in fuel consumption and emissions.