Tips and Technology
For Bosch business partners

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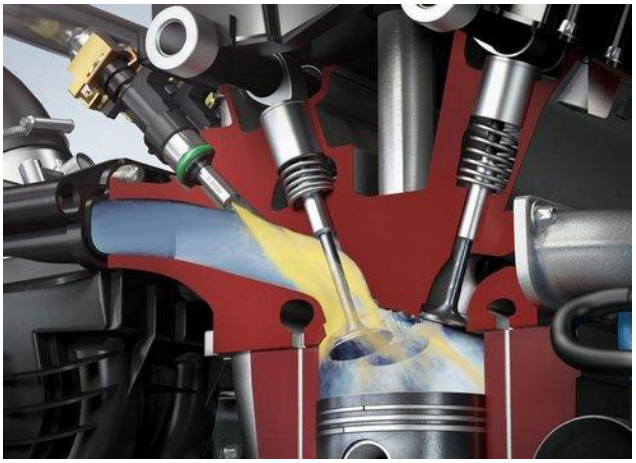
Gasoline Injection

BOSCH
Invented for life

Gasoline injection systems: How the market for direct injection is developing, and why port fuel injection still has a future

Port fuel injection systems: cost effective, with potential for the future



Market situation: In 2012, roughly 60 percent of all newly manufactured vehicles featured gasoline port-fuel injection. Bosch is the world's largest manufacturer of injectors, supplying some 70 automakers worldwide with its systems.

How it works: In gasoline port-fuel injection, the air-fuel mix is created outside the combustion chamber, in the injection manifold. The injector injects the fuel upstream of the intake valve. During the intake phase, the air-fuel mix is drawn in through the open intake valve into the combustion chamber. The injection valves are selected in such a way that the engine's fuel requirements are covered at all times – also under full load and at high speeds. However, even when idling, small volumes of fuel can be precisely metered and injected.

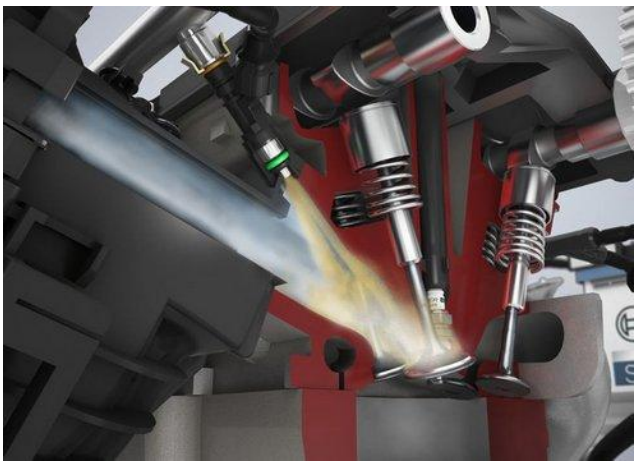
All-rounder: A special variant of the Bosch EV14 injection valve also features in the latest Bugatti Veyron model. This example shows that port fuel injection is also suitable for extremely powerful vehicles, and even for super sports cars. The Bosch EV14 injection valve's nine variants mean that it can be used in a variety of applications. Some of them also feature in price-sensitive vehicle segments and markets, and even in personal water craft.

Future markets: In markets such as Brazil, China, and the Asean countries, port-fuel injection is still on the rise, as vehicle numbers show. Bosch is already positioning itself in this market, and will start manufacturing injection valves in Jakarta in 2014, for example.

Mature technology: Bosch can look back on 45 years of experience in manufacturing port fuel injectors. Bosch supplied its first valve in 1967, when most vehicles were still equipped with carburetors. Since then, the supplier has manufactured more than 1.3 billion injectors.

Alternative powertrains: Even in electrical powertrains, port fuel injection will still play a role. This is because it is less expensive than direct injection, and any efficiency deficits will be offset by the electrical components. Port fuel injection is also the basis for alternative-fuel powertrains such as the Bosch CNG systems or flex fuel – in other words, the components of the ethanol powertrains that are mainly sold in South America.

Advanced port fuel injection: economical systems approach



Advanced port fuel injection: Bosch has developed four individual approaches to improving gasoline port-fuel injection. This cost-effective systems approach can reduce fuel consumption by as much as 12 percent. In addition, advanced port fuel injection (advanced PFI) can improve torque and engine performance. Using this system, therefore, drivers can reduce fuel costs while experiencing greater driving enjoyment at the same time.

Scavenging: In this approach, a higher exhaust-gas velocity at low engine speed brings forward the operating point of the exhaust-gas turbocharger. This means the turbocharger can respond earlier, as there is a sufficient flow of exhaust gas. In this way, the often-cited turbo lag can be avoided. This is because scavenging improves the intake of fresh air, and a greater volume of hotter exhaust gas is delivered to the turbocharger's turbine. When combined with downsizing and turbocharging, scavenging can bring about a fuel saving of some 10 percent.

Open valve injection: In this approach, the fuel is injected into the fresh air streaming into the intake manifold during the induction cycle. As a result, the fuel is vaporized in the combustion chamber, reducing the temperature there. Open valve injection thus makes a higher rate of compression possible. Fuel consumption can be reduced by 2 percent in this way.

Fuel pressure: When starting the engine, fuel pressure is increased to allow a more homogeneous mix to be created. During a cold start, for example, system pressure increases to 6 bar. This improves atomization, and means that less fuel is deposited on the wall of the intake manifold. In this way, the Bosch advanced PFI system reduces hydrocarbon emissions by roughly 20 percent.

Twin injection: In this final approach, each intake duct is fitted with two injection valves. Twin injection means that the fuel is atomized even more finely. This allows the air-fuel mix to be injected far more efficiently and flexibly. Twin injection also helps to reduce the amount of fluid deposited as a film on the intake manifold walls. Moreover, scavenging is only possible in port fuel injection if there is twin injection.

Gasoline direct injection: powerful and growing in popularity

Growth market: In 2002, just 2 percent of vehicles featured gasoline direct injection systems. One decade later, this figure was 22 percent. In 2012, Bosch supplied more than 5 million gasoline direct injection systems. By 2015, this figure will be more than 9 million. In this segment, Bosch is growing by 50 percent annually, and currently generates sales of 1.3 billion euros. This business will continue to grow in the future. Especially in the U.S., this technology is very much in demand.

How it works: Engines with gasoline direct injection prepare the air-fuel mix directly in the combustion chamber. All that flows through the open intake valve in the intake duct is fresh air. High-pressure injection valves inject the fuel directly into the combustion chamber. This cools the combustion chamber, making basic compression higher and reducing propensity to knock. The economical consumption and low emissions of gasoline direct injection are due to the precise metering, preparation, and distribution of air and fuel for each individual combustion cycle.

Efficiency: Gasoline direct injection is one of the key components for fulfilling future emissions standards. Modern injectors play an essential part in optimizing the inner workings of engines, and thus in reducing pollutant emissions. In the future, increasing pressure to more than 200 bar could bring further advances. The Bosch HDEV5 injector already works at a pressure of roughly 200 bar.

Customer benefit: In combination with downsizing and turbocharging, gasoline direct injection reduces consumption, and thus CO_2 emissions, by as much as 15 percent. In combination with downsizing, turbocharging, and scavenging, gasoline direct injection provides an impressive improvement in response, as well as improved driving performance. This is because torque is increased by as much as 50 percent.

Pioneering achievements: Bosch is regarded as the pioneer of gasoline direct injection. Bosch launched this technology in 1951, initially for the two-stroke engine of the compact Gutbrod

Superior car. Three years later, gasoline direct injection debuted in the four-stroke engine of the legendary “gullwing” Mercedes-Benz 300 SL.

Production: In 2011, the 25 millionth injection valve and 5 millionth high-pressure pump rolled off the production lines in the Bosch global manufacturing network. And in 2012, Bosch celebrated two further production milestones: 50 million injectors and 10 million high-pressure pumps.