press release

KOLBENSCHMIDT PIERBURG

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Pierburg GmbH

Two-stage turbocharger system

Exhaust gas recirculation (EGR) as a means of reducing NO_x emissions poses varying challenges regarding component design and fine-tuning. For Euro 6 and Tier 4 final, due to take effect starting from 2014, an EGR system is necessary to ensure functioning of, and act as an addition to, the SCR system (Selective Catalytic Reduction of nitrogen oxides). On commercial vehicle diesels, the high-pressure EGR mode is used.

These new types of EGR require modified turbocharger design as well as faster and reliable sensors and actuators. For this purpose, Pierburg GmbH provides its two-stage charger (PTTS) (Pierburg Twin Turbo System). In conjunction with the exhaust flow sensor and the motorized EGR flap valve this plays an important role in emission reduction as it combines the high efficiency of the individual parts with their optimum interaction.

EGR and turbocharging are two processes that interact both between each other and via the engine in a variety of ways. The engine’s operation is governed by its upstream and downstream gas pressures, these in turn being determined by the turbocharging and EGR processes.

So that the EGR process need not be curbed, the turbocharger must quickly make available fairly large volumes of air. During acceleration at high recirculation rates and pressures, the rapid and precise control of the gas is especially important since under these conditions any minor deviations can cause major fluctuations in emissions. This can only be ensured by turbocharging systems with a high degree of dynamic response which are combined with sensors and actuators likewise quick and precise in their response. With their multi-stage compression, two-stage or twin turbo systems offer fuel economies and a high degree of flexibility in their response to engine needs. In terms of pressure and temperature, EGR can be configured in the best possible way, given the existing parameters. Two-stage turbochargers develop high start-up torque and good response which, in turn, in combination with a motorized flap valve and low pressure losses and a robust exhaust gas sensor, allows compliance with high standards of dynamic response and precision within a closed loop system.

Challenging turbocharging demands

To reroute exhaust gases from the exhaust to the intake side of the engine, we need the right ratio between intake (charge) and exhaust counterpressure.

The difference in pressure must be created by suitable turbocharger design. However, rising exhaust pressure also means higher fuel consumption and so this leads to a conflict of objectives that needs to be resolved. Furthermore, the achievable EGR rate hinges on the efficiency of the EGR cooler, the recirculated gas passage and the system's EGR and check valves, with special emphasis being placed on low pressure-losses because otherwise losses would have to be compensated by the turbocharger.

The engine's exhaust gas drives the turbine which, in turn, feeds the engine with compressed air via the compressor seated on the same shaft. With high-pressure EGR, some of the exhaust is diverted upstream of the turbine and rerouted to the engine, passing the exhaust cooler on its journey. This process requires an adjustment to the turbine to allow for the lower mass flow. For this purpose the turbine must operate at high efficiency so that any added fuel consumption through excessive counterpressure is averted.

Various forms of charging

The turbocharger's design depends on combustion air supply as dictated by the combustion process, plus dynamic/braking requirements. Options include single-stage charging by a fixed exhaust gas turbocharger, with or without wastegate, single-stage turbocharging (again exhaust driven) but with variable turbine geometry, and two-stage turbocharging with fixed or variable geometry for the high-pressure turbine.

It is a fact that EGR has for years now been successfully employed as an internal emission-reduction measure. Improved fuel grades and EGR-tolerant combustion methods have also contributed to increased use over the years. It is also expected that to comply with pending Euro 6 and Tier 4 final, EGR will be required in addition to selective catalytic reduction (SCR) of the nitrogen oxides. This allows fuel savings while ensuring compliance with emission standards throughout the engine's life and under all operating conditions.

In recirculating inert gas into the cylinders, EGR causes a reduction in combustion temperature and hence lower rates of NO_x formation. These effects hinge on such factors as mode of combustion and operation (cold start, engine and ambient temperatures, torque requirements). Combining EGR with SCR likewise has its advantages. At low temperatures under part-load conditions, SCR systems require an increase in temperature; this can be achieved with a variety of measures but all of them linked to extra fuel consumption. Fuel savings by additionally using EGR with SCR systems are possible provided the exhaust gas temperatures are sufficiently high. These result from the combustion mode and are linked to catalytic converter and filter temperatures for arriving at satisfactory levels of efficiency. Under part-load conditions, EGR brings about further fuels savings by "unthrottling" the engine.