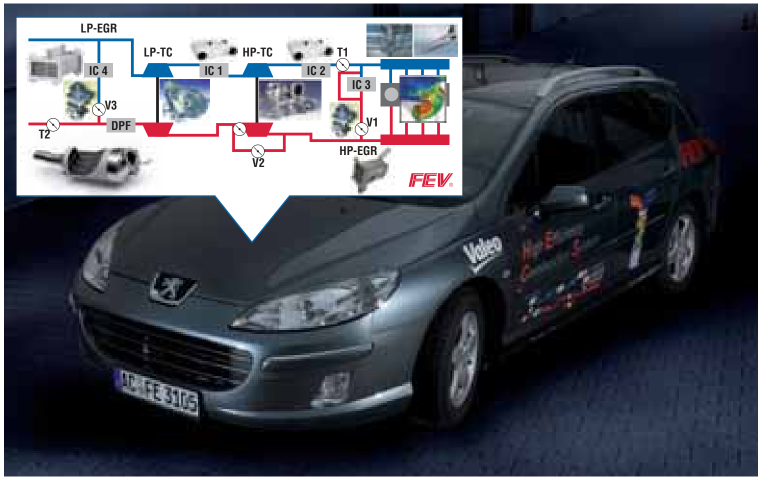

Modern Diesel Engine Performance Potential with the Lowest Raw Emissions

Within the last couple of decades, the modern DI diesel engine has proven to be an economical and attractive alternative in the modern passenger car segment. This is attributable to its higher process efficiency and torque characteristics. The recent rise in consumer acceptance of the DI diesel engine is a result of improved drivability and acoustics, which has contributed to the reduction of fleet fuel consumption as a part of the ACEA voluntary commitment. This has been achieved by maintaining its traditionally low fuel consumption, while also fulfilling strict emission regulations. The combination of recent indications of climate change that are linked to the use of fossil fuels and the rising fuel prices, has brought fuel consumption into the limelight for the entire spectrum of manufacturers and their development teams.

To meet the continuously increasing demands resulting from this situation, the combustion system also needs to be redesigned. This measure is necessary, so that the disadvantages of exhaust aftertreatment systems (for example, DPF) can be minimized through significantly reduced engine-out emissions, thereby raising fuel efficiency. FEV analyzed all of the design parameters of the diesel combustion system in detail and evaluated them for future demands. The solution became the development of the FEV combustion system, **HECS** (**H**igh **E**fficiency **C**ombustion **S**ystem), which is designed and tailored for high EGR tolerance, combining low nitrogen oxide emissions with superior fuel efficiency, even under high part load conditions.

The following are the primary elements of this optimized combustion system layout:

- Optimization of mixture formation (fuel injection and swirl)
- Improved cylinder filling with optimized gas exchange (boosting, manifold layout and flow losses)
- Highly capable boosting system, in conjunction with a combined high pressure and low pressure EGR system
- Adjustment of the combustion chamber (geometry and compression ratio) to the air and fuel system capabilities
- Intensified cooling (Air and EGR)
- Implementation of a high performance glow plug system

The information gathered from the process analysis forms the foundation for the design of an in-house prototype engine. A commercially available 1.6L, 4-cylinder engine, with optimized components and subsystems, serves as the platform for this project (title figure). The appropriate application of the technology packages, permits the replacement of an equally powerful 2.2L 4-cylinder engine motor with the modified 1.6L aggregate that is fitted with two-stage exhaust gas turbocharging, thereby achieving maximal fuel saving.

The careful layout of the combustion chamber geometry, with the aid of modern CFD tools ensures an ideal air utilization even within the nominal speed

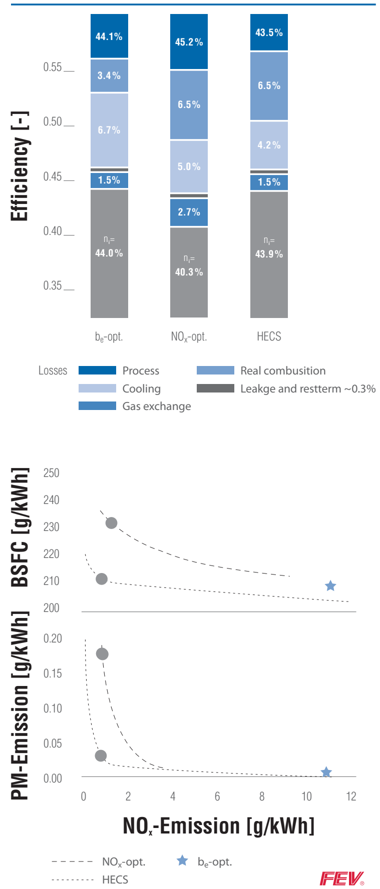

Fig. 1: Emission Performance and Efficiency of the HECS Engine (Part Load Point @ ~2300 rpm)

range. The realization of air-fuel ratios of nearly 1.1 at engine speeds above 3500 rpm is proof of the significant improvement over the state-of-art. In comparison to the larger base engine, an improvement in low end torque is possible through the combination of carefully laid out process parameters, such as charge motion, spray pattern and piston bowl shape. In addition, flexible multiple injection and two-stage turbocharging also improve low end torque, in spite of the reduction in engine capacity. Improving the gas exchange and significantly lowering charge temperatures leads to a shift toward leaner air-fuel ratios. Substantially increased EGR rates result, which permit a major reduction in untreated emissions.

The improved NO_x/be trade-off can then be targeted separately from an improvement in the NO_x/PM trade-off. (s. Fig. 1).

The lowest possible NO_x emissions can be obtained through the integration of a new, model-based control concept and the subsequent linking of these structures to innovative approaches to control combustion, with the help of an integrated pressure sensor and glow plug, allowing a near ideal configuration of combustion parameters. In addition, the considerably improved PM emissions guarantee longer regeneration intervals for the DPF, contributing to a further rise in fuel efficiency for everyday operation.

For the purpose of a complete analysis of the potential of diesel drivetrains, the improvements discussed thus far could be combined with developments in other areas. Therefore, the following aspects are of particular interest:

- Optimization of the mechanics and loss reduction (friction)
- Hybrid Development (start/stop, regeneration, power boost function)
- Vehicle improvements (weight, air and rolling resistance)
- Drivetrain optimization (losses in the gearbox and transmission ratios)

The HECS concept, in conjunction with the other technology concepts that are mentioned, could help realize a 40 % reduction in fuel consumption for a mid-sized car (vehicle class: 1590 kg/3500 lbs.) and result in the same or possibly even improved driving comfort.

We are working on a variety of projects to provide further increases in fuel efficiency and reduced emissions for diesel engines, in order to facilitate the customer's individual mobility. Apart from innovative concept vehicles and demonstrator vehicles, we are working on a variety of production development programs for the worldwide automotive market. We look forward to assisting you in achieving your goals.

koerfer@fev.de