Mixture Formation and Homogenization of TC-DI-Gasoline Engines

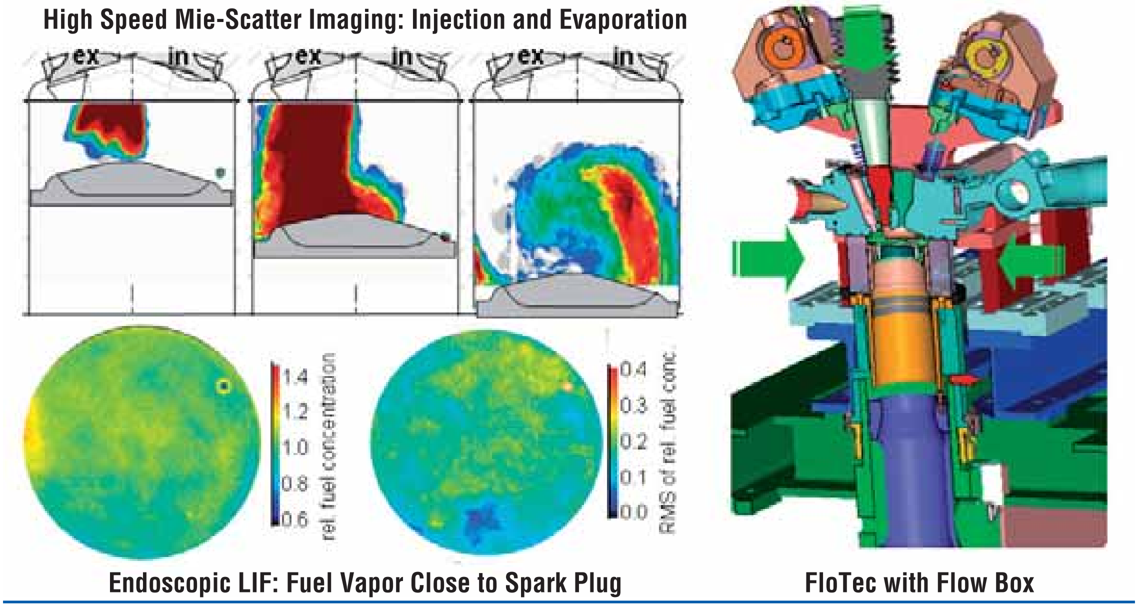

Fig. 1: Optical High Speed Diagnostics for the Boosted FloTec Test Bench

The trend towards downsizing has lead to additional challenges related to combustion system optimization. FEV has developed a methodology to front-load the initial functional optimization of a combustion system using a combination of analytical tools and high-tech empirical test devices. This approach can substantially reduce the required development time for combustion system optimization.

Downsizing of gasoline engines is a comparatively simple and cost effective way to reduce CO_2 emissions, as seen by the modern downsized powertrains that are in production. To further exploit this potential, the degree of downsizing has to be increased. However, additional downsizing causes several new challenges for turbocharged (TC), direct injection (DI) gasoline engines, including the thermo-mechanical load capacity, charging system performance and the combustion system. The combustion system must be capable of delivering high specific power, while meeting emissions legislation and without the occurrence of irregular combustion. The small bore diameters of downsized TC-DI engines require a finely balanced mixture formation, which prevents liner wetting and provides a well homogenized mixture to inhibit poor combustion, excessive emissions and problems due to deposit build-up on the combustion chamber surfaces.

During the combustion system development phase, FEV utilizes a series of tools that allow the proof and initial optimization of various functions to be front-loaded to occur early in the development phase.

Included in these methods are the charge motion optimization with the CMD process (see SPECTRUM 37) and injector layout using the FEV-ILT (Injector Layout & Targeting) tool. FEV has developed an adapted optical diagnostics program to experimentally investigate different geometry and injector variants, providing a detailed analysis and assessment of the mixture formation prior to the availability of the first prototype engine. These measurements are performed on the FloTec motored engine test bench, which uses rapid prototyping metal flow boxes instead of a cylinder heads. External valve actuation enables oil- and water-free operation of the flow boxes.

As soon as the first concept layout of combustion chamber design and injector definition has been determined, in-cylinder charge motion and mixture formation can be analyzed by combining PIV, Mie scattering and LIF diagnostics on the FloTec test bench. The FloTec is equipped with variable injector inserts and quickly exchangeable piston crown modules in order to rapidly develop an appropriate spray - flow interaction at various loads. Also, the interaction is developed under special conditions, such as during catalyst heating operation, with a fast adaptation of the injector targeting in combination with the piston bowl design. Using high-speed PIV and Mie scattering diagnostics, cyclic fluctuations can be recorded and quantitative measures of the cyclic stability of charge and injection can be determined, including their reverse interaction.

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