講演番号	027

文献番号	20226027

Optimization of Hydrogen Internal Combustion Engine Powertrain by means of Simulation

Tsuyoshi Horiba [1)] Hirohide Misu [1)] Hiroshi Kageyama [1)] Lukas Virnich [2)]
Sharareh Schaub [2)] Stefano Ghetti [2)] Dieter Van der Put[3)]

1) FEV Japan Co., Ltd., 1008 Burex Kojimachi, 3-5-2 Kojimachi, Chiyoda-ku, Tokyo, 102-0083, Japan
2) FEV Europe GmbH, Neuenhofstraße 181 Aachen, 52078, Germany
3) FEV Group GmbH, Neuenhofstraße 181 Aachen, 52078, Germany

KEY WORDS: **heat engine, Spark ignition engine, compression ignition engine,** numerical calculation, hydrogen internal combustion engine [A1]

In the ongoing race for CO2-neutral powertrain solutions, the hydrogen combustion engine is gaining increasing interest, especially for commercial powertrain applications. Compared to full electric or fuel cell electric solutions, the hydrogen combustion engine uses existing and optimized production processes to a large extent and does not raise concerns about the raw materials required. To meet the challenges of hydrogen combustion engines, powertrain hybridization offers great potential. This can increase the attractiveness of the powertrain beyond its current focus.

This paper outlines how the powertrain combustion layout has been optimized for various commercial engine use cases to resolve the trade-off between transient performance and achieving near zero pollutant emission. The degree of hybridization, different turbocharger technologies, the injection method (port fuel injection (PFI) and direct injection (DI)), and different exhaust gas aftertreatment layouts have been investigated using a dedicated H2 ICE simulation tool chain to identify tailored powertrain solutions for a variety of use cases.

Compared to PFI, the time for mixture preparation for DI is shortened, and hence a lower level of mixture homogeneity is achieved. Consequently, the possibility for rich areas increases as well as the tendency for knock. Thus, a major challenge for DI systems is to provide PFI-like mixture homogeneity. Other advantages of the DI technology relates to lower NOx emissions at constant boost pressure at the same efficiency as PFI, as well as improved transient response. The mixture formation is key to enhance engine efficiency while keeping the NOx raw emissions low. The interaction between fuel injection and charge motion determines the homogeneity of the mixture.

A tailored hydrogen combustion simulation tool chain was applied to optimize the mixture formation. To further develop the simulation tools, experimental data from test engine and low-pressure optical chamber investigations are continuously being validated against simulation results. An example of mixture formation optimization with the calibrated injection model is shown in Figure 1. As can be seen in the lefthand side of Figure 1, the hydrogen is trapped on the outside near the cylinder liner due to the base swirl inside the cylinder. The tumble motion generated by the injection is not strong enough to bring enough hydrogen towards the center of the combustion chamber. As a result, poor homogeneity is observed in the cylinder. As part of the optimization of the mixture formation, the swirl from the ports was reduced to almost zero. The injector cap design was readjusted to produce more tumble. The combination of these changes was sufficient to significantly improve mixture homogeneity as can be seen in the right-hand side of Figure 1. To achieve optimal results, a comprehensive hydrogen combustion simulation tool chain must be applied within the confines of each engine.

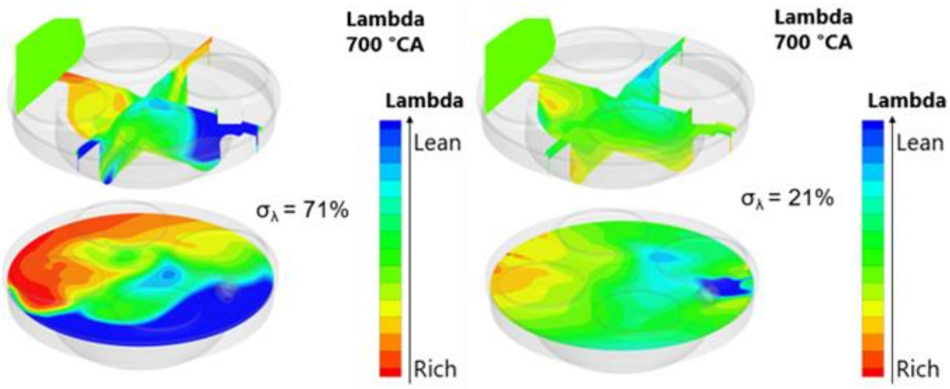

Fig. 1. Mixture formation optimization with 3D CFD