PaREGEn

Particle Reduced, Efficient Gasoline Engines

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Summary

In this report a comparison between port water injection (PWI) and direct water injection (DWI) is presented over the knock limited engine operation range. The performance of the engine with water injection is compared to the performance without water injection. The test engine is the Daimler PaREGEn prototype engine with a compression ratio of 13.5:1. All test were performed at the BOSCH testing facility in Schwieberdingen.

The parameters varied are the water injection timing, the number of water injections, the variation of the injected water mass and the water injection pressure. Furthermore, four different DWI spray targeting were evaluated

For PWI no influence of the water injection timing on the engine behaviour was found. It is known from other engines with PWI that a different PWI injector mounting position and a different spray targeting might lead to an influence of the water injection timing, where an optimal timing with higher water efficacy can be found. With such a mounting position the knock mitigation capability of PWI especially at lower engine speeds was worse than the capability of DWI. At high engine speeds and high engine power, PWI showed a comparable performance to DWI and it has to be expected that the performance might become better than DWI with an adapted injector mounting position.

Contrary to PWI, DWI showed an explicit influence of the water injection timing. An injection end during the compression stroke always proved to be the optimal injection timing. Multiple water injections further improved the performance of DWI. Also, the spray targeting of the DWI injectors had a significant influence on the performance of DWI. A compact water spray, which is designed for less liner wetting, results in the highest MFB50%-shift (mass fraction burned timing) and lowest indicated specific fuel consumption (ISFC) with the least water required.

It was shown that DWI can be further improved by increasing of the water injection pressure.

DWI was able to achieve an MFB50%-shift of up to 14 °ca and an ISFC improvement of up to 11 % compared to the engine operation without water. PWI only showed a MFB50%-shift up to 7 °ca and an ISFC improvement of up to 5 % at lower engine speeds. At high engine speeds and rated power, no significant performance difference between PWI and DWI could be found.

With only minor deductions in ISFC reduction compared to the optimal ISFC, the required water to fuel ratio can be limited to values of less than 60%

Summarising, the results lead to the fact that under stationary engine operation at the test bench DWI has performance advantages compared to PWI at lower engine speeds. At high engine speeds, no performance difference could be observed.

For PWI, some adjustments are already known to further improve the performance, e.g. PWI injector mounting position. Since the system complexity of a DWI system is a lot higher than the complexity of PWI, a clear recommendation for the use of a DWI over a PWI system in such an engine cannot be made.