Introduction

The investigated natural gas-diesel engine is a gas engine where the premixed air-gas mixture is ignited by a small amount of directly injected diesel fuel. The concept can be realized by modifying a production type diesel engine slightly through the addition of natural gas port injectors. The natural gas-diesel engine has proven its potential of highly efficient operation with low CO2 emissions on the test-bench of the Institute for Dynamic Systems and Control.

The used engine is a Volkswagen industrial engine with a 2-liters displacement volume and a cylinder. Since the used engine is a conventional Diesel engine, the operation strategy has been adapted in the operation range accordingly to figure 3. Figure 3 shows the energy share of natural gas and pilot Diesel fuel. Even though, the end of injection of pilot fuel is long time before start of combustion, with high share of pilot fuel, significant soot emissions are produced. In this used strategy, the occurred at the lower load range.

Comparison of OME and Diesel

Figure 8 compares the heat release rates of an operating condition at 900 rpm and 8 bar brake mean effective pressure (BMEP) with either Diesel or OME as pilot fuel with similar injection settings (This means: similar fuel mass but different energy share). The global stoichiometry is one for both pilot fuels. At this load, the percentage of pilot fuel is already very low, thus, lower energy content of OME only minor influence the stoichiometry of the premixed natural gas. However, the impact of the pilot fuel on the combustion is very high. The ignition delay is lower, the cetane number of the pilot fuel and the natural gas combustion is faster. The latter effect can be attributed to the higher temperature, since the combustion is closer to top dead center. Furthermore, the stoichiometry of the natural gas is closer to which increases the flame speed.

Particulate Matter (PM) and Particulate Number (PN) Emissions

In the lower load operating condition, as depicted in figure 3, the share of pilot fuel can be up to 70%. The large amount of pilot fuel causes two major effects. The mixture of natural gas needs to be very lean (slow flame speed) and the core of the auto-ignition zone is fuel rich. The latter one cause high PM emissions. The figures 10 and 11 show a comparison between different engine settings at a bar BMEP with high EGR ratios, according to table 1.

Conclusion and Outlook

A dual fuel engine has been operated with natural gas, premixed as main, and Diesel as well as OME as pilot fuel. The used OME blend contains OME 2, OME 3 and OME 4. This particular blend has an 5% higher cetane number. Furthermore, the OME blend has a higher cetane number. The operation with Diesel as pilot fuel show shorter ignition delays and a faster combustion in comparison to similar operating conditions with Diesel. Using Diesel, the operation in the lower load range requires a high share of pilot fuel. This has a negative effect on the CO2 as well as on soot emissions. Due to the shorter ignition delay, the operation with OME allows a higher share of pilot fuel. Moreover, the oxygen content of the fuel inhibits formation of soot almost completely. Therefore, the exhaust emissions of the operating conditions with OME do not show PM or PN.