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On the Way towards Decarbonization – Green Fuels, Hybridization and Digitalization in Large Engine Applications

On the Way towards Defossilization of Diesel Engines

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The highly efficient Diesel engine is state of the art in many areas, especially in heavy-duty applications, in the industrial sector or in the marine area. An increasingly critical view due to the emission of greenhouse gases and harmful pollutants requires an investigation of alternatives to conventional Diesel fuel. Oxygenated synthetic fuels such as oxymethylene ether (OME) are a promising approach to reduce these emissions and to turn the Diesel engine into a sustainable powertrain concept. The soot-free combustion of OME allows an optimization of the combustion process towards minimum emissions and maximum efficiency. Climate neutrality of the fuel is achieved by using renewable energies and binding of existing carbon dioxide, for example through the conversion of biomass.

The fuel was investigated on a heavy-duty single-cylinder research engine, which was additionally modified for fully optical accessibility. The fuel system was adapted for the use of OME, and injectors with a larger nozzle flow were used to compensate for the reduced volumetric lower heating value of OME compared to Diesel fuel. The optical experiments showed that, in contrast to Diesel fuel, no soot luminosity is detectable with OME, even with poorer mixture preparation, as it occurs at low injection pressures. In addition, earlier ignition and faster combustion can be observed, which are due to the shorter ignition delay and the high oxygen content of OME, respectively.

To optimize emissions and efficiency, several engine parameters were varied with OME. Unlike Diesel fuel, even high rates of exhaust gas recirculation (EGR) do not lead to increased soot formation. The soot-NOx trade-off is thus resolved for OME, allowing a high level of in-engine minimization of NOx emissions. This is also achieved by the measures of lowering injection pressure and reducing boost pressure, with no soot formation occurring either. The promising combustion properties of OME further enable the use of Miller valve timing. Here, the intake valves are closed well before the bottom dead center. This leads to a reduced combustion temperature, which in turn results in reduced NOx formation. At the same time, engine efficiency is increased. Tests have shown that nitrogen oxides can be reduced by up to 40 % in this way, while at the same time efficiency is increased by more than 3 %. In combination with Diesel fuel, on the other hand, the use of Miller valve timing proved not to be reasonable, as the lower combustion temperatures lead to an increased tendency to soot formation. By combining this measure with reduced injection pressure and boost pressure, nitrogen oxides are lowered by up to 60 % for OME. This opens up the possibility of a simplified engine without the need for EGR, with the remaining nitrogen oxides being removed via exhaust gas aftertreatment (selective catalytic reduction).

The studies have shown that OME is a promising substitute for conventional Diesel fuel. By optimizing the combustion process, the lowest possible emissions can be achieved, which in combination with a closed carbon cycle makes the fuel a sustainable option for future mobility.