Future alternative transportation fuels

Objectives

Fuels from renewable resources (e.g., biomass) are considered a possible solution for securing a fossil free energy supply in the future while helping to reduce unwanted greenhouse gas emissions. Drop-in fuels are designed to enable the use in standard compression ignition engines without changes in hardware or calibration settings. This project aims to evaluate the potential of drop-in fuels on the CI combustion regarding engine performance and emission. Therefore, potential fuels candidates are investigated in heavy and light duty engines, as well as with optical techniques. Focus on the fuels choice are blends consisting of long-chain alcohols, hydrotreated vegetable oil (HVO) and rapeseed methyl ester (RME).

Method

Engine settings and operation conditions

Experiments were performed on a heavy duty CI single cylinder research engine equipped with cylinder head D13 from Volvo. Further a single cylinder light duty engine was used. Standard engine settings were applied for all fuel blends and fossil Diesel fuel served as reference.

Optical settings

Future alternative fuel candidates were studied in an optically accessible high-pressure/high-temperature chamber under non-combusting (623 K, 4.59 MPa) and combusting (823 K, 6.04 MPa) conditions. Injection pressures were set to 120 MPa and 180 MPa and the gas density was held constant at 26 kg/m^3.

Fuel properties and blending

Fuel blends were designed to mimic the properties of standard Diesel fuel, in particular the cetane number was held constant. Fuel components chosen were two C_8-alcohols (n-octanol and its isomer 2-ethylhexanol) and two C_{10}-alcohols (n-decanol and its isomer 2-propylheptanol) because of their high heating value and the possibility of a sustainable production. The long-chain alcohols were blended with hydrotreated vegetable oil (HVO) and rapeseed methyl ester (RME) or fossil Diesel. The percentage of fossil Diesel in the blends was 0%, 10% or 20%.

Results

Heavy duty engine experiments revealed that the performance of different blend compositions resembled standard Diesel regarding the indicated thermal efficiency and rate of heat released. Owing to the lower heating value of the fuel blends, the specific fuel consumption of the blends was slightly higher. The yields of HC and NOx did not vary significantly for the different fuel blends compared to Diesel, while CO and soot emissions reduced. The lowest soot emissions were achieved with the fully renewable fuel composition, which did not contain any aromatic structures.

Optical tests in the spray chamber revealed a lower soot formation of the blends compared to the reference fuel (see Figure 1). Combustion behavior and thus soot formation is strongly influenced by the oxygen content in the fuel, as well the share of aromatic structures and the heat of evaporation.

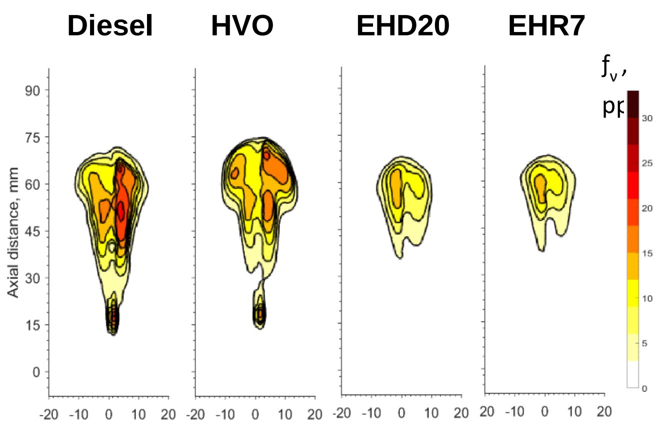

Figure 1: Soot volume fraction, ppm at combusting condition (550°C, 4.6 MPa, pinj = 120 MPa) , 1.5 ms ASOI.
EHD20: 36 % 2-Ethylhexanol + 44 % HVO+ 20 % Diesel,
EHR7: 43 % 2-Ethylhexanol + 50 % HVO + 7 % RME

Overall, the obtained results indicate that blends containing long-chain alcohols, HVO and RME could be a potential replacement for fossil Diesel fuel. Emissions, especially soot, where significantly reduced, while maintaining engine performance.