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

Experimental analysis of the influence of current and future marine fuels on particle emissions

Uwe Etzien[1], Testbed Engineer
Niklas Gierenz[1], Bert Buchholz[1], Ralf Zimmermann[2, 3], Thorsten Streibel[2, 3], Thomas W. Adam[3, 4]

[1] University of Rostock, Lehrstuhl für Kolbenmaschinen und Verbrennungsmotoren, Rostock, Germany
[2] Universität Rostock, Lehrstuhl für Analytische Chemie, Rostock, Germany
[3] Helmholtz Zentrum München – Deutsches Forschungszentrum für Gesundheit und Umwelt, Munich, Germany
[4] Universität der Bundeswehr München, Institut für Chemie & Umwelttechnik, Neubiberg, Germany

With the last tightening of the IMO regulations on January 1st 2020 (sulfur content in fuel ≤ 0.5% or the use of an exhaust gas cleaning system also outside of the ECAs), a change in the composition of the fleet emissions and the fuel supply is to be expected. In this context, the joint project SAARUS was launched at the University of Rostock, with the aim to investigate ship-based emissions and to reduce them through optimized and expanded exhaust gas cleaning. In addition to reducing SOx emissions, the focus is on separating fine particles that measure less than 2.5 µm (PM2.5). In particular, the health-endangering fine dust fractions (aerosols) with particle diameters below 1 µm are only slightly reduced by conventional wet scrubbers. The approach to further decrease the particle load is therefore to use the scrubber as an optimized particle prefilter to create the boundary conditions for downstream filter technologies. Therefore, an extensive measurement campaign with six different market available fuels took place on a representative medium-speed single-cylinder research engine of the Chair of Piston Machines and Combustion Engines at the University of Rostock. As part of the investigations, the fuel-based changes in emissions and the combustion behavior of a hydrogenated vegetable oil (HVO), a MGO, a limit-compliant HFO (sulfur content ≤ 0.5%), a standard HFO (sulfur content 2.4%) and two highly aromatic heavy fuel oils (sulfur content 0.06% and 1.3%) are analyzed. The focus was on the characterization of the particle load in terms of mass concentration, number, size distribution as well as chemical composition. The following measurement methods were used to determine the particle emissions: gravimetric filter analyzes, tapered element oscillating microbalance (TEOM), scanning mobility particle sizer (SMPS), Pegasor particle sensor, online single particle mass spectrometry (SPMS), filter sampling and two-dimensional gas chromatography / mass spectrometry (GCxGC-TOFMS), high-resolution mass spectrometry (HRMS for organic matter) and inductively coupled plasma / mass spectrometry (ICP-MS for elements). The presentation focusses on the most important findings of this measurement campaign. Especially the influence of the different fuels on the particle load in terms of concentration, size distribution and chemical composition is shown. In a final outlook, the approach for the 2nd measurement campaign and the simulation approach for particle separation in the scrubber are presented.