The Influence of Fuel Sulfur on the Operation of Large Two-Stroke Marine Diesel Engines

The present work focuses on SO3/H2SO4 formation and sulfuric acid (H2SO4) condensation in a large low speed 2-stroke marine diesel engine. SO3 formation is treated theoretically from a formulated multizone engine model described in this work that includes a detailed and validated sulfur reaction mechanism. Model results show that for a large marine engine generally about 3% - 6% of the fuel sulfur converts to SO3 while the remainder leaves the engine as SO2 from which the SO3 is formed during the expansion stroke. SO3 formation scales with the cylinder pressure and inversely with the engine speed as also demonstrated by a number of SO3 experiments described in this work. The experiments are carried out with a heavy duty medium speed 4 stroke diesel engine operating on heavy fuel oil including ≈ 2 wt. % sulfur. SO3 was measured successfully in the exhaust gas with the PENTOL SO3 analyzer and experimental results are used for a rough validation of the theoretical model. Gaseous sulfuric acid does not form in the hot cylinder/bulk gasses but more exactly from a fast reaction between SO3 and H2O at the cooled cylinder liner surface and modeled information about SO3 formation is applied in order to examine the characteristics of acid condensation on the liner surface. In this respect acid dew point temperatures are determined by implementing two-phase equilibrium of the H2O-H2SO4 system. Residual gasses are typically responsible for the peak rate rates of condensation as well as the maximum dew point temperatures that generally range between 190 °C – 225 °C depending on the operational conditions and fuel sulfur content. Independent of operational conditions the most aggressive acid condenses within the first 50 crank angles after top dead center due to the high cylinder pressure.

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