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Impact of Gasoline Surrogates with Different Fuel Sensitivity (RON-MON) on Knock Prediction

Corinna Netzer[1,*], Lars Seidel[2], Harry Lehtiniemi[3], Frédéric Ravet[4], Fabian Mauss[1]

[1] Thermodynamic and Thermal Process Engineering, Brandenburg University of Technology, 03044 Cottbus, Germany, corinna.netzer@b-tu.de, fabian.mauss@tdtvt.de, www.b-tu.de
[2] LOGE Deutschland GmbH, 03046 Cottbus, Germany, lars.seidel@logesoft.com, www. logesoft.com
[3] LOGE AB, Lund 223 70, Sweden, harry.lehtiniemi@logesoft.com, www. logesoft.com
[4] Renault S.A.S, 91510 Lardy, France, frederic.ravet@renault.com, www.group.renault.com

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Modern Spark Ignition (SI) engine development is dominated by the trade-off between maximizing the fuel efficiency and avoiding harmful engine knock. More and more frequently, CFD simulations are used to find the optimal operating conditions close to the knock limit to support test bench development. Beside the engine design and operating mode, the fuel quality has a major impact on engine knock. The auto-ignition tendency of the fuel is determined by the Research Octane Number (RON) and the Motored Octane number (MON), and their combination is referred to as octane sensitivity S=RON-MON. In simulations often Primary Reference Fuels (PRF) are applied to predict engine knock. Their composition of iso-octane (RON =100, MON =100) and n-heptane (RON = 0, MON = 0) can be used to compose a surrogate that represents the RON of a commercial gasoline fuel, but never at the same time the correct MON or octane sensitivity. Therefore, in recent years the use of reaction schemes for Toluene Reference Fuels (TRF) and ethanol containing Toluene Reference Fuels (ETRF) were proposed. Thanks to a third or fourth fuel species, surrogates with close agreement in RON, MON and octane sensitivity to real gasoline can be formulated.
In this work, we analyse the effect of different surrogates on the engine knock prediction. Surrogates composed of different species (PRF, TRF, ETRF) are compared to each other. The applied surrogates have all the same RON, but differ in MON and other characteristics as H-C-O ratio and density. Through this analysis, the effect of the different gasoline characteristics on engine knock prediction is evaluated. The aim is to understand how sensitive the predicted knock intensity, the knock onset timing and the knock limit spark advance is to the surrogate composition.
The auto-ignition is calculated based on an ETRF reaction scheme from Seidel [1]. The 3D CFD calculations are carried out using CONVERGE 2.4. The flame front is modelled using the G-equation based on tabulated laminar flame speeds. In the unburned zone a homogenous model is used to predict the auto-ignition. A post-processing strategy is used to evaluate the character and the severity of the auto-ignition event based on the detonation theory by Bradley et al [2].

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