Renewable diesel spray modelling

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Abstract

The use of petroleum fuels has a triple negative effect: local - air pollution; regional - acid rain; global - greenhouse effect. Given the foregoing, as well as due to limited global sources of oil, interest in alternative and renewable fuels is increasing. Hydrotreated vegetable oil (HVO) and (HWSO) are synthetic non-oxygenated alternative diesel fuel from renewable biomass sources using hydroprocessing to convert bio-oils to paraffinic hydrocarbons.
HVO and HWSO (or renewable diesel) do not contain sulphur and aromatic constituents. Renewable diesel fuel has different thermodynamic properties than diesel fuel. The cetane number of such fuels is higher than that of diesel fuel, while the lubricity is lower as well as fuel density.

LP-model was used to analyse the spray characteristics of renewable diesel. This model is based on a length parameter (LP) and takes into account the physical properties of fuels such as viscosity, density and surface tension. The Sauter mean diameter (SMD) of droplets in the spray of different alternative diesel fuels was calculated using LP-model. Renewable diesel spray shows the smallest SMD and biodiesel spray has the largest SMD from all fuels that were investigated. The reason of this that renewable fuel has the smaller LP-parameter compared to biodiesel, diesel and their blends.

The maximum spray penetration or "liquid length" for HVO and HWCO compared to FTD (Fischer-Tropsch diesel), GTL (gas to liquid), B100 and diesel fuels were analysed using simple empirical model. This model includes the fuel properties such as fuel density, specific heat and latent heat of evaporation. Renewable diesel spray shows the shortest penetration that is very close to diesel fuels one.

Ignition delay of renewable fuel compared to diesel and biodiesel fuels was investigated using model that based on Arrhenius type equation. In case of present a long-chain alkanes in the structure, the renewable diesel will have a very high cetane number. The correlation of ignition delay with cetane number was established and activation energy for both renewable and biodiesel fuels was calculated. The modelling shows that the ignition delay time for renewable diesel at low temperatures is shorter than for diesel. At higher temperature (> 1000K) the ignition delay for renewable diesel is very close to diesel fuels and biodiesel. All models show a reasonable agreement with experimental data that were evaluable.

Keywords: spray, SMD, renewable diesel, LP model

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