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LES investigation of engine operation with a multicomponent reference fuel at knocking conditions within the NTC regime

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In the strive for higher efficiency, modern engine technologies such as downsizing are yielding promising results. However, a higher tendency to knock can be observed. The pressure oscillations associated with knocking combustion are a potential source of engine damage. This limits the operating range and thus the efficiency of an engine. With a better understanding of the processes at the knock limit, the combustion process can be further optimized.

Experiments are conducted on a single-cylinder research engine operated at the knock limit. Fueled with a Toluene Reference Fuel, numerical investigation of the operating points is possible. Using an OpenFOAM® engine framework, a multi-cycle engine LES study is performed to investigate combustion and auto-ignition. Modeling of the turbulent flame propagation is based on a flame surface density (FSD) approach coupled to a flamelet-generated manifold. A precursor model is used to predict the auto-ignition process in the unburned mixture. The incorporation of tabulated chemistry together with a detailed source term description allows to capture the complex auto-ignition kinetics of the surrogate fuel. A two-stage auto-ignition behavior is observed. The model predictions agree well with the observed experimental trends concerning combustion and auto-ignition.