(1-08) Numerical Study of n-Heptane Spray Auto-Ignition at Different Levels of Pre-Ignition Turbulence

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ABSTRACT

It is reported in [1] that in n-heptane spray auto-ignition at constant volume under Diesel-like conditions is substantially affected by the pre-turbulence level. In these experiments, different levels of initial turbulent kinetic energy were generated using a multi hole plate that was moved through the combustion chamber. The turbulence generator was calibrated by LDA. The ignition delays were determined by studying the light emissions in the UV and visible wave length range by optical fibers and a photomultiplier. It was also possible to modify the pre-ignition level of turbulence by the injected spray especially in the regime of pilot injection. To evaluate these effects, a numerical study was done using the detailed chemistry approach incorporated into the KIVA-3 spray combustion code.

The basic novelty of the proposed methodology, see [2, 3], is the application of a generalized partially stirred reactor, PaSR, model, to treat detailed oxidation kinetics of hydrocarbon fuels assuming that chemical processes proceed in two successive steps: the reaction act follows micro-mixing simulated on a sub-grid scale. If the all Re number RNG k-ε model is employed, the micro-mixing time can be consistently defined giving the combustion model in a "well-closed" form.

The detailed mechanism integrating the skeletal n-heptane oxidation chemistry with the kinetics of aromatics (up to four aromatic rings) formation for rich acetylene flames [4], consisting of 117 species and 602 reactions, was validated in numerical kinetic analysis, and the reduced mechanism (60 species, including soot forming agents up to the third aromatic ring and NOx species, 237 reactions) was used in the spray combustion simulations. The model application was illustrated by comparison of predicted and measured ignition delays at constant volume at different levels of pre-turbulence, and good agreement was found (see Fig. 1). Different definitions for the ignition delay were compared and the best agreement was achieved, when the start of ignition was defined as the moment when the average temperature in the combustion chamber exceeds the initial temperature by 1%. The moderate increase in the level of pre-turbulence leads to a reduction in ignition delay owing to more rapid mixing in forming the ignitible mixture. This effect was also pronounced when the "pilot" injection with different injection schedules was analyzed.

![Graph](image)

Fig. 1: Comparison between experimental and calculated results.

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