Modeling the Transient Structure of Non-Reacting and Reacting Diesel Sprays

C. Bajaj, M. Ameen, J. Abraham*
School of Mechanical Engineering, Purdue University, West Lafayette, IN 47907-2088, USA
bajajc@purdue.edu, mameen@purdue.edu, jabraham@purdue.edu

Abstract

Modeling the transient structure of reacting diesel sprays accurately is important within the context of multidimensional modeling of flows, sprays, and combustion in diesel engines. In the case of non-reacting vaporizing sprays, vapor jets have been shown to reproduce, with adequate accuracy, the structure of the diesel jet beyond the maximum liquid length of about 100 orifice diameters in high-pressure injection into high-pressure high-temperature environments. In this work, the primary focus is on reacting diesel jets. An unsteady flamelet progress variable (UFPV) model for reacting diesel jets is evaluated. The UFPV model has been proposed for predicting the averaged/filtered chemistry source terms in Reynolds averaged simulations (RANS) and large eddy simulations of turbulent non-premixed combustion. In the model, a look-up table of reaction source terms is generated as a function of mixture fraction Z, stoichiometric scalar dissipation rate χ_{st}, and progress variable C_{st} by solving the unsteady flamelet equations. The formulation assumes that the shape of the $\chi(Z)$ profile can be modeled by an error function which remains unchanged in the presence of heat release. It is also assumed that the probability density functions (pdfs) of Z, χ_{st}, and C_{st} are statistically independent, and presumed functions are employed for the pdfs. Changes in injection pressure, ambient temperature, ambient density, orifice diameter, and ambient O_2 concentration are considered. It is shown that the model is able to predict ignition delay and flame lift-off with reasonable accuracy for all conditions. The ability of the model to predict the lift-off height appears to be related to the mechanism by which the flame propagates from the ignition location to the final stabilization plane along the stoichiometric surface.

* Corresponding author: jabraham@purdue.edu