

Abstract

The main objective of this work is the modeling of the turbulent combustion process of diesel-like sprays including the autoignition event and the quasi-steady flame structure. For this purpose, a combustion model based on the flamelet concept and embedded in a RANS environment is implemented in the CFD platform OpenFOAM. The implemented modeling approach follows the idea of an unsteady flamelet/progress variable (UFPV) model. In such models, the underlying assumption is to suppose that the structure of a turbulent flame can be described by a set of laminar diffusion flames (flamelets). Igniting and extinguishing solutions of such flamelets in opposed jet configuration are studied. The mixture fraction Z , the scalar dissipation rate χ , and the progress variable Y_c are key parameters in the description of unsteady flamelets. The transition of the mixture from the inert state to the stable reactive state is described unequivocally by Y_c . Moreover, an interesting method to calculate approximated diffusion flames (ADF) is studied with the objective to reduce the computational effort especially for complex fuels.

The subgrid turbulence-chemistry interaction is accounted for by means of presumed PDF modeling. In doing so, the joint statistical distribution of the mixture fraction, the stoichiometric scalar dissipation rate, and the progress variable is assumed. The outcome of this *a priori* calculation step is stored in a turbulent flamelet database. Four lookup parameters are required during a calculation run to obtain thermochemical properties from this pre-calculated table: the mean mixture fraction and its variance, the mean stoichiometric scalar dissipation rate, and the mean progress variable. Furthermore, two different ways of coupling combustion model and CFD code are presented.

First, the model is applied to the turbulent lifted H_2/N_2 jet flame experiment from Berkeley University. This laboratory flame is a widely used test case in the area of turbulent combustion modeling. Good agreement between computational results and experimental data is observed. Moreover, also the simplified version of the combustion model based on ADF solutions is successfully tested and encouraging results are obtained.

Finally, the simplified combustion model is applied to the experimental series of "Spray H" from the Engine Combustion Network (ECN). The calculated ignition delay and lift-off length are compared with experimental data, and the influence of ambient temperature on these two characteristic flame parameters is studied. Furthermore, the quasi-steady flame structure, predicted heat release rates, and species mass fractions are analyzed in detail.