Experimental and numerical study of monodisperse ethanol mist combustion

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Ethanol is a promissing alternative to fossil fuels, which can be obtained by fermentation of biomass products. While ethanol was subjected to wide research, ethanol spray combustion with a controlled dispersion composition is not yet comprehensively studied. In the current work, we present a combined experimental and numerical study of monodisperse ethanol mist combustion.

The experimental setup consisted of a nozzle with Vitoshinsky profile, a jet of an air-ethanol mixture, and fine mist with different concentrations created by an ultrasonic mist generator. The combined Particle image velocimetry (PIV) and Planar laser-induced fluorescence (PLIF) study was performed to determine the laminar flame speed.

The numerical simulation was performed using the “sprayFoam” solver from OpenFoam (www.openfoam.com) open-source CFD package. The solver utilized a mixed Eulerian-Lagrangian approach, where the droplets are simulated as Lagrangian parcels and the gas phase is resolved on a fixed (Eulerian) grid. For the gas phase, a reduced chemistry model was used with resolving of 66 chemical reactions for 31 species. For spatial and temporal discretization, a second order implicit scheme was used (central differencing for space and Crank-Nicolson for time derivatives, respectively).

The simulation was performed in 3D for Reynolds number of 1000, approximately 10^7 grid nodes and solitary Lagrangian parcels. The inlet diameter of the droplets was chosen to be 14 10^{-6} m which is consistent with the experimental data.

We compare numerical and experimental data. For the droplets phase, the advection, collision (coalescence), and evaporation processes were considered. The temperature profiles and flame height were compared between those obtained with simulation and experiment.

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