Simulation of Evaporation and Combustion of Droplets using VOF methods

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Abstract

The main purpose of this work is to describe the unsteady behavior of chemical reacting liquid fuel droplets in a forced convective environment. As proposed e.g. by Zhang and Gogos [1] n-heptane is considered as model substance. According to the work of Schlottke and Weigand [2] the volume of fluid approach (VOF) is used to describe the liquid phase. Adding a volumetric source term in the VOF equation allows to simulate evaporation of the liquid. This term is converted to a mass source term used in the species equation for the n-heptane gas phase. Additionally, four more species equations are calculated to evaluate mixing due to diffusion effects and consumption and production due to chemical reaction. Finally, heat transfer is implicated solving an energy conservation equation with specialized source terms regarding reaction and evaporation enthalpies.

The numerical model has been validated against analytics, experimental and numerical data. To compare with analytical solution the simulation of evaporation of a single water droplet in a quiescent atmosphere under certain simplifications of properties and different temperatures has been performed. The results have shown almost perfect agreement with the d^2 law described e.g. by Turns [5]. In the case of convective flow the simulations generated similar results compared with experimental data presented by Nomura et al. [3] and simulated by Zhang and Gogos [1]. In a last case the combination of evaporation and combustion has been simulated for a 3D droplet array inspired by Dwyer, Stapf and Maly [4] in order to compare results of simulated flame temperature with adiabatic one.

Key words: Evaporation, Combustion, VOF

References

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