Large Eddy Simulation-Probability Density Function modelling of nucleation and condensation of DBP droplets in a turbulent jet

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Abstract

Homogeneous nucleation and growth of dibutyl phthalate (DBP) droplets forming in a turbulent jet are modelled using LES combined with a probability density function/Monte Carlo method. LES resolves the largest turbulence structures but small scale processes like droplet nucleation and growth require closure. The Monte Carlo particles represent the gas temperature and species mass fractions, as well as the particle size distribution (PSD) of the DBP droplets. Thus all nucleation and growth terms are in closed form and the Interaction by Exchange with the Mean (IEM)-mixing model is used to account for the scalar mixing of the particles within each LES cell. The (physical) particle ensemble is represented by discrete size bins on each (stochastic) Monte Carlo particle. The LES-PDF method reproduces the experimental data well, and an analysis of the nucleation and growth terms demonstrates that the correlations of the large turbulent scales must not be ignored when modelling the averaged nucleation rate. In contrast, the large scale correlations do not significantly affect the particle growth, but the small scale, LES-subgrid term notably reduces particle growth for a wide particle size range.

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