METHOD MONTE CARLO FOR TWO-PHASE TURBULENT FLAMES

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INTRODUCTION

The existing models of two-phase combustion are based either on considering two penetrating and interacting continua in Eulerian manner or on considering a carrier phase in Eulerian and the dispersed phase in Lagrangian manner. In the both approaches the spatial resolution of phase interaction processes is governed by the eulerian grid size. As a result, non-uniformities in spatial distribution of dispersed phase, which are very important in reactive flows, are smeared out over a computational gridd, and a number of intrinsic physical and chemical phenomena appear to be unresolved. This paper deals with the generalization of the earlier authors paper [1], where the new methodology was suggested and tested. Contrary to existing methods, the new method is based on considering both interacting continua in Lagrangian manner. In this formulation, it becomes possible to follow the trajectories of condensed phase and gas phase particles and incorporate into analysis the intrinsic feature of the interphase exchange processes, that is the finite depth of interphase fluxes.

APPROACH

In the Lagrangian terminology, the gas phase is represented by N_G gas particles while the dispersed phase by N_P condensed particles. It is implied that $N_G \gg N_P$. Gas particles are characterized by mass, set of x, y, and z coordinates in physical space, three velocity components u, v, and w, density, and a set of scalar properties (species concentrations and enthalpy). Condensed particles are represented by mass, the set of coordinates X, Y, and Z in physical space, three velocity components U, V, W, and enthalpy H.

For the either sort of particles, the governing equations are formulated in terms of differential trajectory equation, and equation of mass, momentum, and energy conservation along the particle trajectory. Interphase mass, momentum and energy fluxes are assumed to be localized within a compact spatial domain («action sphere») attached to either particle. Scalar dissipation and viscous stresses in gas phase are modeled by applying simple relaxation-to-local-mean and Langevin models, respectively. Simple one-step homogeneous and hetegeneous chemistry is applied to simulate exothermicity of two-phase flow.

Numerical solution of the resultant problem is accomplished using the Monte Carlo method. Mean values required for modeling interphase fluxes are computed by applying smoothing splines.

RESULTS

The goal of the currenr study is to simulate ignition and flame kernel convection and groth in a free turbulent jet of two-phase mixture. Direct comparison of predicted results with experimental observations [2] shows that the new method is capable of providing information on the structure of combustion zones in the reacting two-phase flow. At low loading ratio, condensed particles are likely to be surrounded by individual flames. At higher loading ratios, distrinct combustion zones enveloping ensembles of particles were observed in calculations. Combustion reactions were found to be sensitive to turbulence intensity. Local flame quenching and reignition was detected and analized.

The method provides extensive statistics. A whole variety of joint single-point probability density functions will be presented and discussed.

1. *Rose M., Roth P., Frolov S.M,. Neuhaus M.G., Klemens R.* Langrangian Approach for Modeling Two-Phase Turbulent Reactive Flows // In: Advanced Computation and Analysis of Combustion / Eds. G.D.Roy, S.M.Frolov, P.Givi. Moscow: ENAS Publ., 1997. PP. 175-194.
2. *Mitgau P., Wagner H.-Gg., Klemens R.* Investigation of Flame Propagation in Turbulent Flow of Premixed Methane, Hybrid and Dust Mixtures // Proc. 26th Symp. (Int.) on Combustion. Napoli. 1996.