LARGE EDDY SIMULATION OF A PILOTED DIFFUSION FLAME WITH FLAMELET COMBUSTION MODEL IMPLEMENTATION

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Large eddy simulation with a flamelet combustion model is one of viable options for device-scale simulations due to its significant reduction of computational cost with a reasonable representation of turbulent combustion. The flamelet approach for non-premixed flames, which views a turbulent flame as an ensemble of laminar flamelets, was suggested by Peters [1]. In flamelet approach, turbulence-combustion interaction and detailed chemistry are mapped by several representative parameters on laminar flamelet database instead of solving entire species equations. Various modified flamelet approaches are categorized by the set of parameters used [1-3]. For the present study, mixture fraction, mixture fraction variance and specially constructed progress variable are used as representative parameters. Mixture fraction is the most important parameter representing entire detail chemistry and acquired by solving a mixture fraction transport equation. Mixture fraction variance is modelled using algebraic equation to consider SGS turbulence-combustion interaction. To apply non-equilibrium effect on detailed chemistry, progress variable is used as parameter and acquired by solving a progress variable transport equation with its source term.
Procedure of new implementation for flamelet approach is presented in Figure 1. The conventional *rhoreactingFoam* is modified to solve additional governing equations for representing parameters and get thermodynamic properties, density, and progress variable source term by flamelet library prepared in advance. A flamelet library for turbulent combustion is acquired by integrating one-dimensional laminar flamelet solutions using beta-PDF integration. One-dimensional laminar flamelet solutions are calculated with non-premixed counterflow flame solvers using Cantera [4] and Ember [5] module, which are available in open-source domain.

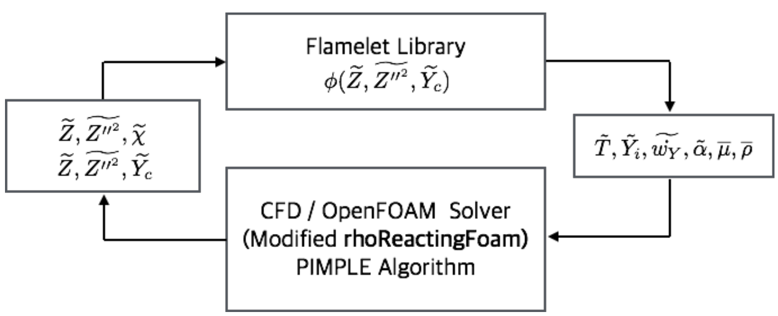

Figure 1: Procedure of numerical simulation with a flamelet approach

To validate the solver, large eddy simulation for piloted diffusion Sandia D flame is conducted and compared with experiment data measure by Barlow and Frank [6]. Computational domain size is 80*D* for axial direction and 26.5*D* for radial direction. In full three-dimensional case, total 3.4 million cells were used. Temperature contour of simulation is presented in Figure 2. Results using the present solver are in reasonable agreement with experiment data for the chosen piloted diffusion flame.

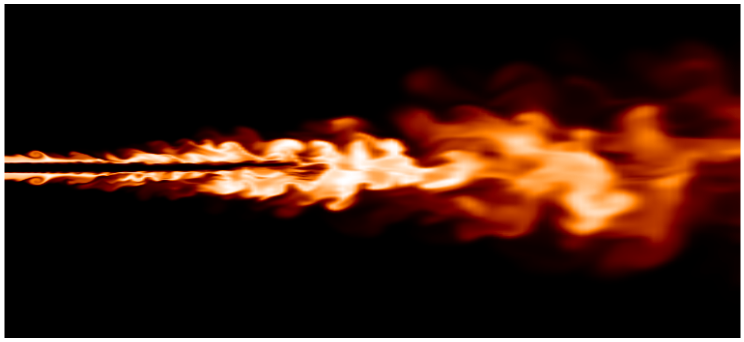

Figure 2: Instantaneous temperature contour of simulation

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