Stochastic Modeling of a Lifted Methane/Air Jet Flame with Detailed Chemistry

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This numerical study investigates a lifted methane/air jet flame in a vitiated coflow by means of the One-Dimensional Turbulence (ODT) model [1]. In the considered Cabra Burner [2] configuration, a jet flame issues from a central nozzle into a vitiated coflow of hot combustion products from lean premixed H2/air flames. ODT is a map-based model for turbulent flow simulations which uses a stochastic formulation for the turbulent advection. The diffusion and reaction effects along the one-dimensional domain are considered by temporally advancing deterministic evolution equations. ODT simulations are performed with a representation of the methane/air chemistry by a reduced 19-species and a detailed 53-species mechanism.

In the talk, we will show radial profiles, centerline profiles, scatter plots and two-dimensional renderings of the jet flame obtained from ODT simulations using the cylindrical formulation [3]. Additionally, the effects of variations of the coflow velocity and temperature on the lift-off height are investigated. Although the simulation of reactive jet configurations by means of ODT is not novel, the complex stabilization region depending on the flow conditions represents a challenge for the model. The accurate representation of the subtle interactions between the hot coflow and the cold unburnt jet are vital for the entire reaction process of the jet. Considering the reduced order of the model, ODT is able to predict the flow characteristics and reasonably matches the existing experimental data.

References

[1] A.R. Kerstein, One-dimensional turbulence: model formulation and application to homogeneous turbulence, shear flows, and buoyant stratified flows, Journal of Fluid Mechanics 392 (1999).

[2] R. Cabra, J.-Y.Chen, R.W. Dibble, A.N. Karpetis, R.S. Barlow, Lifted methaneair jet flames in a vitiated coflow, Combustion and Flame 143 (2005).

[3] D.O. Lignell, V.B. Lansinger, J. Medina, M. Klein, A.R. Kerstein, H. Schmidt, M. Fistler, M. Oevermann, One-dimensional turbulence modeling for cylindrical and spherical flows: model formulation and application, Theoretical and Computational Fluid Dynamics 32 (2018).