Turbulent non-premixed combustion modeling using conditional moment closure including the effects of differential diffusion

Dominic Man Ching Ma and Cecile Devaud

Department of Mechanical and Mechatronics Engineering, University of Waterloo, Waterloo, Canada

Turbulent combustion involves complex phenomenon such as turbulence and chemical reactions. The large range of spatial and temporal scales at which these phenomenon occur in engineering applications make it impossible to fully resolve with the current computational power. Numerical combustion models aim provide feasible solution methods by making assumptions and approximations. A common assumption in turbulent combustion modeling is that of equally diffusing species with a Lewis number of 1, allowing the definition of a conserved mixture fraction. However, in many combustion problems, the substantial differences in molecular diffusivity between the species, known as differential diffusion, were found to have a significant effect on the temperature and species concentrations. Examples include the high diffusivity of H2 and H in hydrogen flames, and the low diffusivity of soot in highly sooting flames. A recent formulation of the conditional moment closure (CMC) combustion model is applied to a RANS simulation of a turbulent hydrogen (H2) jet diffusion flame to model the effects of differential diffusion. Unlike other CMC models which consider differential diffusion, this approach does not require additional transport equations for each differentially diffusing species, which will significantly reduce computational costs. The focus is the validation of the model, and results are compared with a well-documented experimental flame. Current issues with the model are discussed.