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Effects of Mixture Stratification and Preferential Diffusion on Spherically Flames Using Direct Numerical Simulation

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Extended Abstract

The early flame kernel development is crucial for engine performance. In practical engines, lean premixed combustion is usually employed to achieve high thermal efficiency and to reduce pollutant formation [1]. However, the reactants are usually inhomogeneous in practical scenarios due to combustion instability and limited mixing time, featuring stratified premixed combustion. The local flame structure and flame propagation behaviour of the stratified premixed flames are modified compared to those in the homogeneous premixed flames. Therefore, it is necessary to better understand of the development of flame kernel in stratified mixtures.

For non-unity Lewis number mixtures, the existence of differential diffusion in stratified flames can significantly modify the flame structure and flame propagation, and further lead to thermo-diffusive instabilities, which is more evident in stratified hydrogen/air flames. The differential diffusion in early flame kernel development is critical to accurate modelling of turbulent combustion in engines. However, quantitative results of differential diffusion in turbulent stratified flames have not been reported in the literature yet.

In the present work, three-dimensional direct numerical simulations of spherically stratified premixed turbulent lean hydrogen/air flames are employed to clarify the flame structure, flame propagation and the differential diffusion effect on them. A reduced chemical mechanism for H_2/air combustion containing 9 species and 19 elementary reactions is employed. Three flames are considered, *i.e.* the homogeneous flame, the stratified flames with non-unity and unity Lewis numbers. The equivalence ratio the homogenous flame is 0.5 and that of the stratified flame varies from 0.2 to 0.8 with a mean equivalence ratio of 0.5. The temperature of the reactant is 600 K and the pressure is 4 atm.

The general flame structures of various flames at typical evolution times were first presented and compared to explore the effect of mixture stratification and differential diffusion on the flame structures. Then, the differential diffusion behaviour was quantified based on the species transport equations. Finally, the flame displacement speed and its components of various flames at typical evolution times were analysed.

References

[1] Dunn-Rankin, D. (2011). "Lean combustion: technology and control," *Academic Press*.