The Structure of Partially-Premixed Methane Flames in High-Intensity Turbulent Flows

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Abstract

Direct numerical simulations (DNS) are conducted to study the structure of partially-premixed and non-premixed methane flames in high-intensity two-dimensional isotropic turbulent flows. Detailed analysis of the DNS data reveals some of the interesting features of the flame structure and the dynamical behavior of the flame under the intense turbulence field. The results obtained via "flame normal analysis" show local extinction and reignition for both non-premixed and partially-premixed flames. Lagrangian particle analysis indicate that the time integrated strain rate characterizes the finite-rate chemistry effects and flame extinction better than the strain rate itself. It is also shown that the structure of the flame and its extinction are affected by the"pressure-dilation" and "viscous-dissipation" in addition to strain. Consistent with previous studies, regions of high vorticity values are detected close to the reaction zone, where the vorticity generation by the "baroclinic torque" is important. Statistical analysis of the turbulent variables shows that the vorticity field is strongly correlated with the baroclinic torque only at high vorticity zones. The influences of (initial) Reynolds and Damköhler numbers, and various air-fuel premixing levels on flame properties and turbulence are also studied. It is observed that the flame extinction is somewhat similar for flames with different fuel-air premixing. Our simulations also indicate that the CO emission increases as the partial premixing increases. Higher values of the temperature, the OH mass fraction and CO mass fraction are observed within the flame zone at higher Reynolds numbers.

Key words: Turbulent reacting flows, partially-premixed flames, reduced chemistry, DNS, Lagrangian analysis

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